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ELECTRICAL SECTION.

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Electrolytic Receivers in Wireless Telegraphy.

BY DR. LEE DE FOREST.

With the form and nature of the ordinary filings-tube coherer as applied to-day in wireless telegraphy the public has become fairly familiar.

Branley, the distinguished French physicist, discovered in 1891 that the effect of electrical oscillations upon a body of metallic filings, or dust, was to produce a sudden increase in the conductivity of the mass, a conductivity which persisted until the particles were broken apart again by mechanical jar.

Although the American, Varley, the English scientist Hughes, and especially Onesti, the Italian, had previously noted this phenomenon, none of these investigators had fully appreciated the causes involved, or given to the world of science the benefit of their researches in thorough published reports.

The discovery of the "coherer" therefore is rightfully attributed to M. Branley; but to Professor Popoff, of St. Petersburg, and to Sir Oliver Lodge, of England, must be given the credit of applying the relay and mechanical tapper to the filings tube, the addition of antennæ wings, of upright wire and earth connection, and the first steps towards refinement and an appreciation of the possibilities of the new detector as applied to an unborn branch of human enterprise and progress.

With the notable work of Marconi in still further adapting the Popoff-Lodge arrangement to commercial requirements, the gradual increase of distance on which aerographic communication was established, the ingenious improvements in coherers by such men abroad as Tissot, Ducretet, Castelli, then by Lodge and Branley themselves, and in this country by Shoemaker, the audience is more or less familiar.

Enormous is the bulk of research matter published regarding the coherer. Theories of the action involved have been numerous, but divided chiefly into two schools: First, that of Lodge, who demonstrated an actual *welding* together of metallic filings, after the same had been drawn into contact by the electro-static attraction of the opposite charges induced upon the faces of the filings; and, second, that of Branley, who ascribed the action to a breaking down or puncturing by minute sparks of the dielectric film (either gaseous or a metallic oxide), which he held must exist between opposing surfaces of the filings.

The result of the years of investigation which have followed the early work of these two pioneers proves that in a measure both were right. The Branley effect undoubtedly exists, and affords a satisfactory explanation of the self-decohering phenomena observed in the microphone type of auto-coherers. These insulating oxide or gaseous films inevitably form and cling to the surface of any metallic particles not enclosed in absolute vacuum, and where strictest care is not taken to prevent. They are, moreover, elastic, self-healing; and unless the electric impulses are of excessive violence, so that adjacent particles are actually welded firmly together, the original high resistance is automatically

restored upon cessation of the electric impulse. This is notably the case when the elements of the radio-conductor are of carbon, hardened steel, carbon-mercury, aluminum, etc., where the formation of this resisting film is easily accomplished, or where amid the minute roughnesses of the carbon surface the adhesion of a gaseous film is made more easy.

If, however, the coherer consists of filings of some soft metal of relative low fusing point—silver, gold, lead—the Lodge cohering effect through actual welding follows upon the Branley action; making the final fall of resistance far more marked, and necessitating a vigorous mechanical jar to break up the cohered filings, and restore sensitiveness.

It is on account of this enormous change in conductivity of the filings-tube coherer that this form has been the standard used almost exclusively in the coherer systems of wireless telegraphy.

For the filings-tube frequently shows a change from hundreds of thousands of ohms down to a few ohms under the influence of exceedingly weak electrical impulses.

This readily allows the use of a relay, operating a Morse taker and the tapping-back device; and in the old country, where the coherer systems have been chiefly developed, reading by sight has ever been deemed a necessity, especially in the navies, where, until recently, wireless telegraphy has enjoyed its most cordial reception.

The result of all this has been necessarily a system employing delicate relays, tapping-back adjuncts, complications of apparatus, requiring frequent and careful adjustments, a skill and delicacy on the part of the receiving operator seldom found outside of the physics laboratory, least of all upon a man-of-war, where the hands of Jack Tar, of the wig-wag and gundeck school, are all thumbs and of Cyclopic dimensions.

Despite many extravagant claims for high speeds of word transmission by coherer systems, I have yet to see proof of anything exceeding twelve to fifteen words the minute in genuine commercial working, while the actual every-day speed attained seldom exceeds half that amount.

For commercial applications of wireless telegraphy this pathetic speed limitation of itself renders the filings-tube systems to-day an impossibility; regardless of any other considerations, such as uncertainty of their action, ill-adaptability to electrical tuning, liability to interference (notably from atmospheric electricity), harmful effects from mechanical vibrations, etc., etc.

It has been stated by its early champions, and more recently by those prominently interested in *wire* telegraphs, that wireless telegraphy is destined to fill a place where existing methods of wire communication are impossible, such as from ship to ship and ship to shore. And their point was well taken; for, with the best tape-recording coherer systems developed to-day, after eight years of elaborate effort, no sane man would think of employing wireless telegraphy, with its six words and as many guesses per minute, its treacherous adjustments and its moody dispositions, where a wire system could possibly be used.

With the auto-coherer, or so-called microphonic contact, the case is better. Here, since no tapping-back is required, a relay is superfluous, although, to speak frankly, the changes of resistance in the auto-coherer are generally so slight and the *normal* resistance such a shifting quantity that no relay capable of operating reliably with the auto-coherer has been devised. A telephone, the most sensitive indicating instrument known, is invariably used to-day in place of the relay and inker; and, inasmuch as the auto-coherer is usually a quantitative instrument, possessed of no critical voltage, its combination with the telephone affords an extremely sensitive wave detector, the range of which is limited by the sensitiveness of the human ear.

With this arrangement one obtains a speed of word reception limited only by the ability of the operators to send dots and dashes with the transmitter spark, and to translate these into words. Consequently, in America one finds the alternating current of relatively high frequency and excellent regularity of action employed, with an ordinary Morse key obtaining a speed of twenty-five to thirty-five words per minute, instead of the antiquated induction

coil with its spluttering sticking hammer interrupter, or its messy, explosive mercury-brake and the pump-handle *Zeichengeber*, which is considered abroad as a fitting accompaniment to the coherer receiver, and is so well designed to hold down the impatient sender to a sloth sufficient for that form of receiver. As we frequently see in the daily press, the spark-coil coherer systems are excellently adapted to the trying requirements of a "chess game by wireless telegraphy!"

The auto- or microphonic coherer is, however, poorly adapted to the nice requirements of close syntony or electrical tuning. This is on account of its variable normal resistance and its normal capacity. Moreover, this device is liable to "close up" under the effects of severe static discharges, requiring readjustment by tapping, and rendering difficult its employment during time of severe atmospheric disturbances and lightning storms.

Furthermore, its inability to reliably operate by a relay, a bell for calling purposes often necessitates the addition of a filings-tube for that purpose.

I feel justified in saying while on this subject that the type of auto-coherer invented by Mr. Harry Shoemaker, until recently of this city, together with the special antenna which he employs therewith, is the most practical and satisfactory form which has come to my attention.

Having briefly reviewed the field of cohering indicators of electric waves, I wish now to call attention to an entirely distinct line of investigation leading up to forms of receivers which I believe may well be set in a class by themselves as regards sensitiveness, simplicity and general adaptability to most of the demands which can be made to-day in the field of wireless telegraphy. I refer to the electrolytic principle, one which has until recently attracted little investigation from experimenters generally, but which, notwithstanding, has to its credit performances which are rapidly compelling study and research in various sources here and abroad.

In 1898 the German, Neugschwender, performed the following experiment: The silver plating of a strip of mirror

glass was divided into two parts by a sharp razor cut, leaving a narrow gap between two silver edges, completely insulating the two sections. Each of the sections was now connected to the terminals of a dry battery, and a telephone and galvanometer inserted in series in the circuit.

No current was observed to pass until a film of moisture was deposited upon the slit, either by blowing the breath thereon or by placing a saturated sponge nearby or by placing a drop of water directly upon the slit. After a brief period the galvanometer began to show violent and irregular deflections. In the telephone a scratching, bubbling sound was heard, followed shortly by comparative quietness and a stable position of the galvanometer needle, indicating that the resistance of the gap in the silver mirror had been broken down until it measured but a few ohms.

If, now, electric waves were generated in the neighborhood, as from the spark of an induction coil, the galvanometer showed an increase of resistance in the circuit, while the listener in the telephone heard a purring sound, reproducing with singular fidelity the sound of the induction-coil spark.

Upon cessation of the electrical impulses the conductivity of the gap in the mirror instantly reasserted itself; the sound in the telephone ceased.

A year after Neugschwender discovered this strange action of the Hertzian waves, Aschkinass independently noted the same phenomena, the publication of which in *Wiedemann's Annalen* led the former to further pursue his researches, and to examine the action at the moist edges of the silver electrode under a powerful microscope. His observations thereon and my own investigations in 1899 coincide in all essentials, and clearly demonstrate that the phenomenon is one of electrolysis, due to the combined action of the Hertzian and local currents. They demonstrate, however, several features new to the generally accepted idea of electrolytic action; and open up lines of speculation and research of unusual interest to the physicist, and rife with suggestion.

The phenomenon noted above exist to a more prominent degree with tinfoil electrodes in place of silver, and these I shall now attempt to describe.

With the telephone to the ear and the eye at the microscope the action thus doubly observed affords in fact one of the most fascinating, most beautiful pastimes (as I may well term it) ever granted to the investigator in these fields.

When the local E.M.F. is first applied to the gap, minutest metallic particles, all but invisible even with a 1,000-power lens, are seen torn off from the anode, under the stress of the electric forces, apparently mechanical in action; and these dust-like particles, floating in the fluid, move across to the cathode, some rapidly, some slowly, by strange and grotesque pathways, or directly to their goal.

Tiny ferry-boats, each laden with its little electric charge, and unloading its invisible cargo at the opposite electrode, retrace their journeyings, or, caught by a cohesive force, build up little bridges, trees, with branches of quaint and crystalline patterns.

During this formative period (lasting perhaps for half a minute) the ear hears an irregular boiling sound, and the average deflection of the galvanometer indicates a gradual decrease of resistance, until one or more of these tin trees or tentacles has been built completely across the gap.

Then silence ensues until the current across this bridge is suddenly increased as by the Hertzian oscillations from an electric spark made in the neighborhood, or even from a source of so low frequency as the ordinary 60-cycle alternating current.

Instantly all is commotion and change among the tentacles, and especially where these join the cathode. Tiny bubbles of hydrogen gas appear, and enlarging suddenly break or burst apart the bridges, while the click in the telephone indicates the rupture of the current's path.

Yet they are persevering, these little pontoon ferrymen, and instantly re-form, locking hands and hastening from their sudden rout back to build new paths and chains. So the process continues, the local current re-establishing, the electric oscillations breaking up, its highways of passage, with furious bubblings and agitations—a veritable tempest in a microscopic tea-pot.

The hydrogen gas, having, of course, twice the volume of the oxygen, is most in evidence, and therefore the rupture of the tentacle occurs chiefly at its cathodic terminal. And where segregated branches of the tin trees are broken off, the bubbles of gas are generally noticed at the cathodes.

Moreover, the oxygen to a large extent enters into chemical combination with the tin, and after the slit has been used for some time a greyish deposit of stannous oxide may be scraped from the anode.

A peculiar feature of this phenomenon is the rapid disappearance of the gas bubbles. The hydrogen, and what oxygen does not combine with the tin, seems to be absorbed by the liquid; or the two, being nascent, may recombine to form water.

One fact must be borne in mind, that the fine tentacles (whose diameter, by the way, is of the order of some hundred-thousandths of an inch) do not come into actual metallic contact with the anode terminal. A film of electrolyte of almost molecular thickness must exist between the two, conducting normally by electrolytic ionization and conduction, yet easily decomposed and transformed by a sudden *increase* of current into an insulating gaseous film, the expansion of which still further increases the resistance of the gap.

The character of the electrolytic action when soft metals, such as tin, silver, lead, are used as anode, and when the distance to the cathode is decreased to the order of $\frac{1}{100}$-inch or less, is quite surprising. For example, the electro-motive forces needed for electro-deposition from anode to cathode are extremely small, nowhere approaching the critical E.M.F. of polarization of the electrolyte.

Moreover, distilled water, so-called chemically-pure glycerine, oils, etc., contain enough of impurities (such as acid traces) to enable them to act here like our ordinary electrolytic solution. I have in ten minutes plated a firm deposit of tin on a gold cathode, using distilled water only, and a potential difference not exceeding $\frac{1}{10}$ of a volt.

For the same reasons it is possible to decompose the water films interposed between branches of these tin trees

by a very minute difference of potential there-between. The result is that this electrolytic responder does not necessarily possess a "critical potential," as is common to a *coherer;* and it does not, therefore, cease to respond to electric impulses the potential of which is less than the E.M.F. of polarization of the electrolyte, as commonly understood.

This receiver is in fact a *current*-operated device, as distinguished from potentially-operated forms such as the coherer, as I have proved in a variety of ways.

Returning to the silver-mirror slit experiment of Neugschwender, my investigations soon showed me that the device was altogether unreliable as a practical wave-responding detector. In the slit form above described the tearing off of metal from the anode and the building up of conducting bridges and tentacles across the gap was found to continue until the whole gap became clogged with an agglomeration of crystalline formations, affording so many short-circuiting paths in parallel that very soon the auto-cohering could be obtained only in response to powerful sparks.

Again, an accumulation of hydrogen gas may obtain, completely preventing the reforming of a water film between tentacles and electrodes or between sections of the tentacles. There results thereupon the regular coherer arrangement, and at the first electric impulse permanent welding of the chain ensues, so that the device becomes inoperative until cleaned out or readjusted.

Systematic and painstaking experiments extending over two years were required before the electrolytic "responder," as I have termed it, assumed a commercial form.

As described in U. S. Patent 716,000, a viscous supporting medium, such as glycerine, heavy oil, or one mixed with an absorbent such as lycopodium powder, may be inserted between the electrodes to prevent the agglomeration of conducting paths, to confine the action to a few only and to prevent the permanent formation of gas among the tentacles.

In addition a depolarizer was added to chemically dispose of the hydrogen bubbles. This last factor has proved of greatest value, rendering the responder of extreme sensitiveness and reliability.

Other electrolytes, such as dilute acids, alkalies, alcohols, ammonia, etc., were early tried, but I found generally that such lead to a too violent disintegration of the metals in the responder.

It has frequently been asserted that the Marconi coherer when connected directly between the foot of an upright aerial conductor, of about 60 meters height, and the earth, failed to respond to impulses from a typical 12-inch induction-coil transmitter set at distances exceeding twenty miles. For longer distances it was necessary to insert a "jigger" or transformer, by means of which the potential difference across the terminals of the coherer could be stepped up to that required by the so-called "critical potential" of the coherer.

A carbon microphone auto-coherer is a current-operated device. It can, therefore, be inserted without a step-up transformer directly at the foot of the aerial wire, and shows no such failure to respond for the distances above mentioned.

If high-frequency electric oscillations from a distant source be impressed upon a vertical conductor grounded at its lower end, current oscillations will be induced in the surface of the conductor, traversing it from top to bottom. At the upper extremity the electro-static components of the oscillations will be reflected without change of sign, and at the base reflected *with* change of sign. The exact converse holds for the electro-magnetic or current components of the oscillation. The result is a loop of electro-static force at the upper end of the wire, and a current loop at its base. A current-operated device, therefore, will respond best when inserted in the base of the aerial at a point where the *coherer* is at its greatest disadvantage.

The extreme distances from which messages have been received on the electrolytic responder of the types just described, as compared to records with the coherer under similar conditions, afford a practical proof that it is a current-operated device, in addition to the consideration of the electrolytic principles involved in its action.

As an interesting instance of the work done by the re-

sponder under such conditions, I may cite the following aerogram received at the Coney Island Station of the de Forest Company, March 14, 1903, and addressed to President Schurman, of Cornell University. The message was sent by Charles De Garnio, professor of pedagogy in that institution, from on board the S. S. "Coamo," bound to Porto Rico, using a 10-inch coil and an antenna of only 90 feet, the distance being 110 miles: "Greetings from Old Ocean, who no longer sunders friends. Courtesy de Forest wireless telegraph system." Signed.

I call your attention now to a remarkable fact which I have discovered in connection with the electrolytic action of Hertzian waves.

The sensitive cell, as above described, shows nothing of a counter electro-motive force of polarization, although the electrodes may be of a great variety of shape and materials.

The locally applied electro-motive force may range from a few millivolts to 3 volts or more, but always with a proportionate increase of indicated current-flow.

If, however, the electrodes be slowly separated from one another, with one or more of the minute tentacles clinging thereto, a counter electro-motive force of polarization may be observed when the distance between the nearest electrodes exceeds a certain small limit. This counter E.M.F. exists whether the electrodes be of like or unlike material or shape.

Now, upon the first application of the local battery to the terminals of this cell, a temporary flow of current is observed, the resistance of the cell being at first slight, especially if a dilute alkali or acid form the electrolyte. Immediately thereafter, however, the current flow falls almost to nothing; the counter E.M.F. of the cell asserts itself. This, as is well known to the science of electro-chemistry, is due to the formation of a layer of gas insulating the faces of the electrodes. This requires that, unless some depolarizing means be added, the local applied electro-motive force must be raised above the opposing electro-motive force of the cell; that is to say, above the critical voltage required for the decomposition of the electrolyte.

This counter E.M.F. of the cell exists whether the fine tentacles be attached to the anode or cathode.

Now, when the cell is placed in the path of the high-frequency electrical oscillations the effect is found to be a temporary, more or less complete, annulment of the counter electro-motive force of polarization. This effect is scarcely noticeable when the tentacles are made the cathode; but when made the anode, so that oxygen is the gas surrounding and insulating the fine tentacles, the effect of the Hertzian oscillation is to decrease to a marked degree the apparent resistance of the cell.

The sensitiveness of the electrolytic cell to this second action of the Hertzian oscillations is nearly inversely proportional to the exposed area of the anode. It can be obtained even for such coarse anodes as are furnished by a 1 millimeter platinum wire; but the diameter of these is 100 times that of the fine tentacles or trees previously described.

Last year a German experimenter, Schloemilch, reported the independent discovery of this same effect in what he called "polarization cells." Anodes having diameters sufficiently small to give great sensitiveness to the responder are now obtained by mechanical means, using the Wallaston wire having gold or platinum core and a silver sheath; wherewith, after drawing the whole to a fineness of 2 or 3 millimeters, the silver sheath is dissolved in concentrated acid in the manner long known to the arts. The order of diameter thus obtained is comparable to that of the metallic trees built up by electrolytic deposit; but the wire anodes are more stable and better suited to the work in this second type of the electrolytic responder.

To recapitulate these points:

Electrolytic effects of the Hertzian oscillations are available in a practical detector whenever extremely fine tentacles or wires are used for one of the electrodes:

(1) When such tentacle is brought into close proximity of the other electrode, preferably the anode. The normal resistance of the cell then becomes very small, generally a few hundred ohms. The cell offers no counter E.M.F. of polarization. A minute film of liquid intervenes, conduct-

ing by ionization. The passage of the Hertzian oscillation will now decompose this film, insulating the fine electrode, and causing a temporary and marked decrease in the local current flow. This is a current-operated device, and is extremely sensitive when inserted as a potential node, directly at the base of the receiving antenna.

(2) When the anodic tentacle is withdrawn from proximity with the other electrode, of whatever shape or material. The normal apparent resistance of the cell now becomes very great, 30,000 or 50,000 ohms, due to the counter E.M.F. of polarization.

A minute film of oxygen gas normally envelopes the submerged surface of the fine cathode tentacle, practically insulating it. The passage of the Hertzian oscillation will now cause a temporary dissipation of this gas, apparently into the liquid, causing a marked increase in the local current flow. This is a potential-operated device, and is best located where can exist potential loops of opposite sign at its two electrodes.

One investigator, prominent for his inventions in the wireless field, maintains that the phenomenon observed in this second form of the electrolytic responder is a *heat* effect. I have been unable, however, to find a single fact warranting such a view.

First of all, the fact that the device is a valve-effect, not indifferent to the direction of applied local potential, but practically inoperative if the tentacle be made negative, shows that the results obtained are not chiefly C^2R effects, as would be required were the action a heat phenomenon due to the amount of current flowing. Second, that it is a potential-operated and not a current-operated device, possessing a capacity, and normally insulating the fine anode. Third, that its action is sensibly unaffected by extremes of temperature, high or low. Many other considerations, based upon theoretical calculations as well as practical experiment, upon which I cannot dwell at this time, point to the correctness of the explanation of the action involved, based entirely upon electrolytic phenomena.

The electrolytic responders which I have described seem

to possess in the highest degree the qualities necessary to place the art of aerography on a basis to compete with existing telegraphic service, by land as well as by sea. They are extraordinarily sensitive, regular in response, strictly quantitative, automatic in action, having approximately constant normal factors as regards resistance and capacity, allowing thus a speed of word-transmission limited only by the ability of operators to send and receive. By such means the problems of electrical tuning, or syntony, are enormously simplified; for heretofore the erratic nature of the coherer has rendered it impossible to closely regulate the constants of the tuned electrical circuits in which they are placed; thus making syntonization by their employ at best crude and uncertain.

In regularity of action the responder is strictly comparable with the Rutherford magnetic detector as developed by Wilson, Shoemaker, Marconi and Ewing, while as regards relative sensitiveness there is to-day no comparison between that of the magnetic detector and the electrolytic receiver. Moreover, the device is practically indestructible, while its syntonizing qualities enable me to so cut out foreign signals and electric disturbances as to render wireless communication by this means practically immune from interruption.

In corroboration of these statements allow me to call attention to the service which the American De Forest Company has now established between Cleveland and Buffalo. The distance here is 180 miles, extending, as the two stations are located, almost entirely overland. During the recent severe weather, when this land was frozen to a depth of several feet, and Lake Erie a mass of ice extending from the shore for miles (conditions which afford the greatest difficulties for aerographic transmission), the daily exchange of messages at high rates of speed has been continuous. The loudness and clearness of the signals are most surprising, originating, one might suppose, from some station less than 30 miles distant. Tuning here is so close that the addition or subtraction of 6 to 8 inches of wire in the syntonizing coils cuts out the signals altogether and enables the operator to dispose entirely of atmospheric disturbances

arising from severe lightning storms in the close neighborhood of the stations.

During a recent test to Lockport, 36 miles overland from the Buffalo station, messages were received on two small wires extending to the roof of a building but 85 feet above the earth, with the utmost clearness and accuracy.

Again, the recent excellent record which the United States Signal Corps has made between Fort Schuyler and Fort Wright, 98 miles apart, concerning which so much has recently appeared in the daily press, was made with receivers, tuning devices and oscillator sets purchased from the de Forest Companies. As a result of this work, following upon the failure of several coherer systems to cover the distance, the apparatus is to be installed next summer in Alaska between Nome and St. Michaels, over a range which the Signal Corps has sought in vain for several years to cover.*

The exact nature of the electro-magnetic waves by which wireless signals are transmitted has afforded field for a great amount of speculation and theory among scientists and laymen. Considerable interest has attached to the discussion of this subject, which has recently been running in the columns of the *Electrical World and Engineer*.

Unfortunately the classic work in exploration of the field of force and the nature of propagation from the dumb-bell oscillator, by which Professor Hertz immortalized his name, is not entirely applicable to the case; but the analogy is very close. When the lower half of the Hertz oscillator is substituted for a connection of that side of the spark-gap to a conducting or semi-conducting medium of unlimited extent (such as sea water or the earth's surface), the laws of electrical images do not strictly hold.

This was, however, the view taken by Abraham in his mathematical investigation of the subject; by Blondel, at least until recently, and others.

Mr. J. E. Taylor, engineer of the British General Post

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* Since this paper was written these Alaskan stations have been opened. Capt. Wildman reports the system as giving complete satisfaction.

Office, and a zealous pioneer in wireless work, was, I believe, first to apply in a clear and lucid manner the theory and diagrams of Hertz to the case of the grounded oscillator. Taylor pointed out that we had in practice the sliding wave, following in general the shape worked out by Hertz; but with the feet of the lines of force which form the polarized wave-front gliding over the surface of the earth or sea, following the contour of hill and dale; and scaling such obstacles as do not absorb portions of the wave energy and cast thereby more or less serious shadows.

The Hertzian field of force does not call for approximately spherical radiation of energy, as seems to be taken for granted by some; and my own experience goes to show that the falling off in the strength of received energy does not follow anything like the law of the inverse squares of the distance, as this assumption would require.

The electrolytic responder is quite exactly a quantitative instrument, and with it I find, at distances far from the course of oscillations, a decrease in strength of received signals approximately proportional to the first power of the distance.

One fact is certain, that the propagation is not by hemispherical waves. One searches in vain the writings of Hertz for anything suggesting such a theory there. Hertz points out that even with the free polarized wave in space the force diminishes continuously with the inverse distance; at first rapidly, as the inverse cube, but later slowly, as the inverse of the distance itself. So at great distances will the effect of oscillation be marked only in the equatorial plane; that is, in our case, in the region nearest the earth's surface. On the other hand, the electric force in the direction of the axis of the oscillator, or vertically above the radiating antenna, falls off very rapidly, at first as the cube, later as the square of the distance.

Thus, at great distances, an appreciable effect from the Hertzian waves sliding over the earth's surface need not be expected at distances far above the surface. This does not require an hypothesis of the reflecting power of a highly-conducting stratum of rarified air, at an elevation of several

miles, as has been ingeniously suggested to account for the departure of the phenomena from the law of the inverse squares.

Possibly such strata may influence the radiation outwardly into space to some extent. But an exact knowledge of the actual field of force, both on the earth's surface and in the ether surrounding the transmitting station, can only be had by a thorough exploration with detecting oscillators, and under conditions such as obtain in practical, long-distance working; an exploration such as Hertz conducted in the laboratory at Karlsruhe, in that masterly way which so characterized his work.

Such work must obviously be undertaken in a captive balloon or air-ship, and will be attended with obvious and costly difficulties. A beginning was made several years ago by Captain Ferrie, of the French Artillery, but has never been pursued.

With the unequalled facilities offered this summer at the World's Exposition at St. Louis, both as regards a transmitting station of unusual power, or others of lesser range, and as regards vehicles for aerial navigation, it is to be earnestly hoped that more light may then be thrown upon this subject, so full of academic and practical interest.

The results of years of patient experiment, careful research, accompanied often with disheartening failures, on the part of the investigators in the wireless field, frequently fail to meet the full expectations of the public. The difficulties to be overcome can of necessity not be realized by those unacquainted with the exact details of development. Such, alas, has been the history of all invention, all progress. It is gratifying to know that the fundamental obstacles at least are in so large a measure overcome, that development in this, the field possessing perhaps the most popular interest exhibited in any age towards any invention, any discovery, has yet been steady, although at many times slow and faltering.

The difficulties remaining are manifold and great. The development of the past is an earnest of the greater things

which are so surely in store for this new and humanitarian art.

DISCUSSION.

PROF. GEO. A. HOADLEY:—I understand that the Hertzian waves decrease the resistance of the coherer in the Marconi system to such an extent that it is possible to use a local circuit and Morse instrument as a receiver. In this system, since the Hertzian waves increase the resistance of the electrolyte, such an instrument cannot be employed. What is to be used, a telephone receiver?

DR. DE FOREST:—In reading we always employ the telephone with the electrolytic receiver. This combination is the simplest and most sensitive possible and requires no attention or adjustment from the operator. The result is a speed and accuracy of reading impossible by relay; and the trained ear of the operator enables him to instinctively discard false or interfering signals, atmospheric or otherwise, and to attend exclusively to the signals having the distinctive sound of his transmitter spark. We can thus, with two telephones in series, and two operators, read two distinct messages without any other tuning.

A relay can, however, be used with the electrolytic receiver. On account of its sensitiveness and regularity of normal, I use this merely to ring a calling signal. But the records which my system has to its credit, often in competition with tape-register systems, justify, I think, this policy of simplifying the apparatus to the greatest possible extent.

MR. E. A. SCOTT:—In consideration of the fact that the earth, as a mass, is a conductor without resistance, would it not be practicable to make a ground connection with the two stations of sufficiently low resistance to use the earth as a current chute as the water is now used?

DR. DE FOREST:—While the conductivity of the earth as a mass may be considered as infinite, yet only that of the surface lying in the zone of influence from any transmitter station can enter into the question. This conductivity of course varies with the locality, and the quality and dampness of the soil intervening between the two stations. If this chanced to be especially better than the conductivity

of the surrounding country we would find the conducting strip acting in a measure as a "wave-chute," leading a greater portion of the wave energy in that direction than was propagated in other directions of the compass.

Such a condition would be offered in an arid country where the conducting surface was confined largely to the neighborhood of a river or its valley, lying in the line between the two aerograph stations.

A system of railroad tracks would act in this manner, and if both transmitter and receiver instruments were connected to these tracks transmission along the line would be especially good.

MR. CARL HERING:—Would not the presence of large quantities of telegraph wires, or large metal masses, interfere with transmission of your messages?

Would not the submarine cables play a part in trans-atlantic wireless?

DR. DE FOREST:—A mass of horizontally extending telegraph wires would have little effect on the transmission of "wireless" signals if the wires extended at right angles to the direction of propagation.

The lines of static displacement in the wave are vertical, and hence it is only the vertical components in the telegraph wires which would cause a reflection or absorption of the wave energy.

In the case, however, of large vertical masses of metal, such as elevators, gas reservoirs, steel-framed buildings, etc., a very considerable shadow effect of the waves is observed.

This is in accordance with the experiments of Hertz and Lodge on the polarized properties of the Hertzian waves.

On the other hand, if the line of telegraph wires extend in the direction of propagation, they afford a conducting path for the waves, and we find the propagation actually aided, with a tendency to confine or concentrate the energy propagated along that line.

The same thing is noticed in the laboratory, where a simple wire lying along the floor, and not connected either to transmitter or receiver, will greatly aid the transmission, if it lie in the proper directions.

I have noticed the same thing to a marked degree at one of my stations, where a single telephone wire leading into stations extended for several miles in a straight line towards the transmitting station.

It was possible to obtain the messages by connecting the receiver between this wire and earth fully as well as from the 180 feet antenna, although the distance to the transmitter was some 15 miles.

If this wire were extended at right angles to the line of propagation, we would expect no such action from it.

DR. E. GOLDSMITH asked the lecturer whether the earth or the water was not necessary for the transmission of aerial messages; and also whether the high poles built into the ground did not assist to help the transmission; how high have the poles to be in order to send messages across the Atlantic Ocean? It seemed to him that iron ships floating on the water helped in a measure the transmission of the waves.

DR. DE FOREST:—The conductivity of the earth or water surfaces over which the sliding waves are propagated enters very greatly into the phenomena. Therefore is it that we are enabled to operate over greater distances by sea than by land with a given quantity of transmitted energy, other conditions being the same. Moreover, overland the vertical wave-fronts are more or less cut into by obstacles which they there meet—forests, precipitous hill-sides, buildings, metal structures, etc. Every such obstacle absorbs or reflects a greater or less amount of the energy of the waves, depending on the dimensions, conductivity and shape of the obstruction.

It is necessary to extend the vertical transmitting and receiving wires to a certain height, roughly depending upon the distances to be covered. The commonly accepted law is that with a parity of other conditions, the distances attainable are proportionate to the square of the height of the aerial conductors. But to-day a great number of other conditions and arrangements modify this rule.

Signals have been sent across the Atlantic using antenna 225 feet in the vertical, although the length of these

wires is much greater. That height is about the limit to be obtained in practice.

Obviously it is not necessary that the tops of the two masts, or towers, should lie in a line not cut by the curvature of the earth, for reasons already explained.

The distances attainable are nearly proportionate to the amount of energy transmitted, although the length of wave used plays a considerable part. Roughly speaking, the greater the energy the longer the period of oscillation of the radiator circuit, and the greater must be the length and the capacity of the antenna to be in resonance with such periods.

No better grounding conditions can be afforded than those found on an iron-hull vessel floating in sea water. Hence the long distances which are often attained under such circumstances.

ELECTRICAL TRANSMISSION OF PICTURES AND SCRIPT.

A correspondent of (London) *Nature* refers as follows to a method and apparatus for this purpose lately described by Dr. Arthur Korn:

The problem of distant electrical vision is one to which much speculation and experimenting have been devoted. Before this problem can be attempted with any hope of success, however, the preliminary one of the electrical transmission of photographs over a distance has to be solved. This problem, it may be stated at once, has been mastered, and it is now possible to transmit photographs in this manner, and successful results have been obtained over telegraph and telephone lines 800 kilometers long.

It does not need much consideration to see how important such a process would be for journalistic and police work if it could be industrially exploited, and it were possible simply to hand a sketch or photograph in at the telegraph office and send the same as one now sends an ordinary telegram. The evening papers would be able then to publish photographs taken at the seat of war in Korea on the same day. Unfortunately, with the apparatus at present to be had, the time taken to transmit a half-plate photograph is half an hour. The cost of the use of a telegraph line of any length for half an hour would be, it is needless to point out, prohibitive. The lessening of the required time of transmission is, however, simply a matter of further development, and no good reason can be seen why in a few years' time the process should not be an adjunct to every existing telegraph line.

The method shortly consists of the following: A ray of light is made to pass systematically all over the transparent film to be transmitted. After passing through the film it impinges upon a selenium cell the resistance of which varies proportionately to the amount of light which passes through the pho-

tograph. These varying currents pass through the line and are received in a moving coil galvanometer the pointer of which, in moving, inserts or takes out resistance in a high tension circuit, according as the current flowing in the moving coil changes. In the high tension circuit a small vacuum tube is connected, and it follows that the illumination of this tube is proportional to the light passing through the plate at the transmitting end of the line. This vacuum tube now passes over the sensitized photographic paper in synchronism with the ray of light over the transmitted plate, and thus a reproduction of the same is obtained. The transmitted film and sensitized paper are each wrapped on a glass cylinder. These cylinders are rotated by motors, and synchronized once each revolution. Only one wire is needed for the transmission, with, of course, an earth return.

In the case of the transmission of handwriting and half-tone illustrations, the same are got up on metal foil with electrical non conducting ink. A conducting point then travels over the metallic foil, and closes and opens the sending circuit according as it is traveling on a marked or an unmarked place. The receiver used by the author is a modification of that described above, the essential point being the use of the vacuum tube fed with the Tesla currents. The speed reached is 500 written words per hour. For a half-tone illustration a strip ½ centimeter wide and 10 centimeters long can be sent in 100 seconds.

It would seem that there is not very much practical value in the transmission of handwriting; the type-printing telegraph of to-day fulfils all ordinary requirements, and it would be only very seldom that a transmission of handwriting would be required. It is to be hoped, however, that this electrical "distant photography" will make rapid progress.

REGISTERING COMPASS.

A compass which automatically registers minute by minute has been patented by M. Heit, a French inventor. The compass card is fixed on a steel pivot, which rests on a fixed agate, instead of having at its center an agate resting on a fixed steel point. The fixed agate is immersed in a drop of mercury, which serves as a conductor for the electric current that causes the movements of registering. By the use of this instrument it is claimed that a ship's officers have a complete record of a voyage.

FERRO-CONCRETE RAILWAY TIES.

Some interesting tests are being made on the railroad between Voiron and Saint Béron, in France, with ferro-concrete in lieu of wooden railroad ties, to ascertain the comparative initial and maintenance cost, efficiency and durability of these two systems. This track is 3 feet 3 inches gauge, and the ties are 3·9 feet long by 7 inches wide and 5½ inches deep. They weigh 23 pounds each, and cost approximately 50 cents each. The concrete used is composed in the proportion of 33 kilograms of cement to 40 liters of sand, and the reinforcement of steel bars weighs 8·4 kilograms per tie. Under the most unfavorable conditions, it is even considered that the first cost of the ferro-concrete ties will not exceed that of good oak ties more than in the proportion of 5 to 3, while it will be four or five times as durable.—*Scientific American.*

ELECTRICAL SECTION.

Stated Meeting, held Thursday, April 14, 1904.

Telpherage.*

By C. J. Messer,
United Telpherage Company, New York.

The nineteenth century passed into history with a record of such stupendous development from the chimerical to the practical that, even considering all other progress since the world's beginning, it may, with reason, be designated the age of innovation. At its ingress Mynheer Peter Van Stuyvessant "coached it" from Philadelphia to New York, occupying a couple of days in the trip. To-day, his grandson, Peter 3d, wires his agent to meet him at the Waldorf-Astoria at 2 P.M., catches the Washington Express, goes over in two hours, hustles around and borrows a million at 3 per cent., informs his partner in Philadelphia of the transaction by wire—the entire twentieth century accomplishment occupying about five hours.

This is a swift age. In a hundred years the commodity which has experienced the greater advance in price is time. Peter's great-grandfather stopped *en route* a stage occasionally to see his cronies, for in those days one might catch a few odd naps with both eyes without the danger of losing financial or social prestige; but when Peter 3d sleeps he has some one to watch the ticker, for wonderful transformations now occur in a single night.

Time began to advance in price, and all other commodities to cheapen, with the conception of an artificial-power application to mechanism. The ancients, having a plethora of slave labor, simply touched the environment of the science of mechanical dynamics when they invented the water-wheel. It took about 6,000 years for man to learn that fire and water made steam. Before that discovery world-devel-

* The paper was freely illustrated with lantern photographs, a number of which are herewith reproduced.

opment had been carried on through conquest of the weaker by the stronger; but with the discovery, dynamics became the most powerful factor for civilization and progress. In the electric dynamo, the last child of dynamics, however, it would seem that the efforts of all previous energy-dispensing mediums were to be outdistanced.

Time being the most expensive commodity, and electricity the most effective agent in reducing happenings to a due appreciation of that fact, prudent statisticians of producing properties are naturally interested in any device which adds an increased efficiency to their joint action. One of the most attractive of such exhibits now before the public is the conveying system—telpherage.

Possibly there is as little knowledge concerning telpherage in the rank and file of workers in electricity as there is of radium among laymen. Telpherage is a comparatively new science, and the world is large, and to these two facts the busy delver among volts, amperes and ohms may place the blame for his seeming disinterestedness.

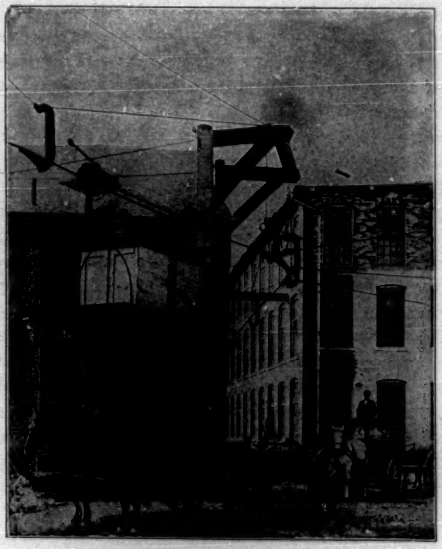
Possibly, again, another decade will not have passed before even the student in electrical matters will be directed to telpherage for a standard in computing maximum force effect in electrical propulsion, for it is a recognized fact among those experts who have examined into the subject that between no other species of mechanics, and motive power, is there such congeniality.

Telpherage means far-carrying, and the word was coined very early in the career of this subtlest of all moving forces —electricity. Some of the first experiments in electric propulsion were worked out on the identical principle of construction as is now so successfully employed in the scheme under discussion.

At the beginning it was decided by eminent authority that in an aerial system of transportation would be found the least obstruction for propulsion by electricity. Prof. Fleeming Jenkin used an elevated structure with suspended load to demonstrate his safety block system, dividing his line into live and dead sections, and making it possible that a train entering one section should cut out that section just

left. By the discontinuance of motive force on that section, possibility of accident from collisions was reduced to the minimum. It was Professor Jenkin who first used the word telpherage as a distinctive name for electric traction on these lines.

The first experiments in electric propulsion were almost wholly confined to freight transportation, but there was to be a wide divergence from this plan before electricity



The old and the new way.

became the docile agent of man's will. A condition existed which offered to the inventor who would improve on the horse railway system of passenger carrying, speedy fame and fortune. When all requirements had been met, capital seemed to lose its head in an effort to get mixed up in the matter, until now we learn from railway commissioners'

reports that the electric street railroad proposition is considerably overdone.

Twenty-five years ago experiments for passenger traffic on this same principle as is now employed in telpherage were carried to a high stage of perfection, but the time was not ripe for success. Valuable street franchises, which had cost nothing, must be utilized.

It may appear inconsistent, but the public domain is of less value than manufacturing property in private hands. In the illustration here shown, the proprietors of the mill could not afford to give space to passageways for teams, and finding something that would allow of a removal of that evil, they later found that they had also been paying too much for conveying.

Telpherage comes under the head of "intermittent control" type of electric propulsion, consequently is best adapted to the action of direct current. In the mill or manufactory, the incandescent plant is utilized, and the cost of operation usually puzzles the mechanical engineer who has been accustomed to figure a 40 per cent. efficiency loss in friction. With a machine and an assistant, a telpherman can convey 250 tons per day over a distance of 1,000 feet. The conveying differs from the general meaning, as attributed to that word, when it is considered that the telpherman takes entire charge of the loading, the carrying and the unloading. How many men and horses would be required in the lifting, conveying and depositing of 250 tons in ten hours, and when all is reckoned, score still an advantage for telpherage, as it occupies space hitherto considered useless in the plant. Snow, ice, or frost thrown surface cannot make more difficult the transportation problem, for telpherage runs in the air. The track is usually at least twenty feet from the ground and the material to be transported is suspended beneath, the supporting arrangement presenting no greater obstruction than would be encountered in an overhead bridge. The telpherman can reverse his machine at will, and when out of commission for even an hour, the plant becomes a non-consumer except in interest charges.

In a general sense, demand for local transportation facilities has never exceeded the supply. Men are plentiful and they can move weights. Horses are especially designed for that purpose, and, following that thought, it is wonderful to consider how far they have been displaced from that for which they were designed, by man's ingenuity, and for the benefit of humanity. It has ever been the rule that a sufficiency in any article hinders development along that line, but what I would now show is that the complexion of the argument changes when an effect on manufacturing economics is considered.

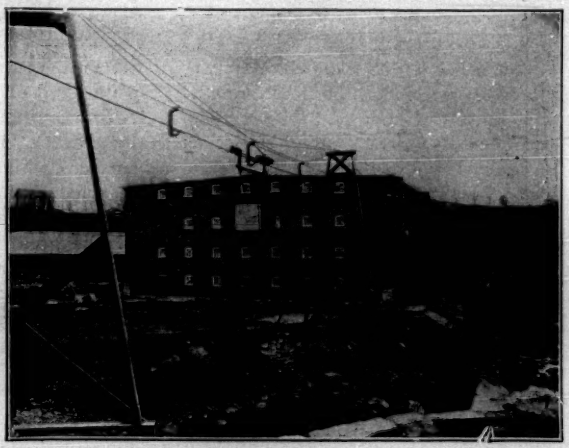
The horse is not an expensive article about manufacturing plants, even though he is idle one-half the time out of a working day, and though his energy is in no way comparable with that of electricity when he is actually at work. It is the preparation of the load for the horse's services, which runs up transportation cost. Even though the price of the horse should be pitted against that of the telpher, advantage would be in favor of the latter on account of the greatly accelerated speed of movement; but I believe it can be easily shown you that there is absolutely no comparison between the values of the two mediums of transportation.

Recently I stood forty minutes to observe the movement of five cases of finished cloth from a packing-room to a storehouse. In the operation six men and two horses were employed. Three men ended the cases upon a truck and wheeled them to the elevator; then a drop was made to the ground floor. The combined effort of five men was used in getting the cases from the elevator to the platform of a dray. A driver handled the ribbons while the load was moving the 600 feet to the storehouse, the five lumpers being part of the load; then, at the other end of the line, the six men were required in the unloading of the dray and the conveying to another elevator, which in two loads took the material to the second story of the storehouse, where men, not accounted for in the illustration, loaded it again and wheeled it to its resting-place.

It was a rather singular analogy that inside the buildings of the various departments of the manufacturing plant, ex-

pensive machinery was being driven to its utmost capacity that the cost of production should be reduced, while here was at least 240 minutes of manual and animal labor expended in a simple problem of conveying. The cost of this operation, not including time of horse, interest on horse, wagon, harness, etc., was at least 60 cents.

I will tell you what that 240 minutes was worth to the manager of that manufacturing plant and to his stockhold-

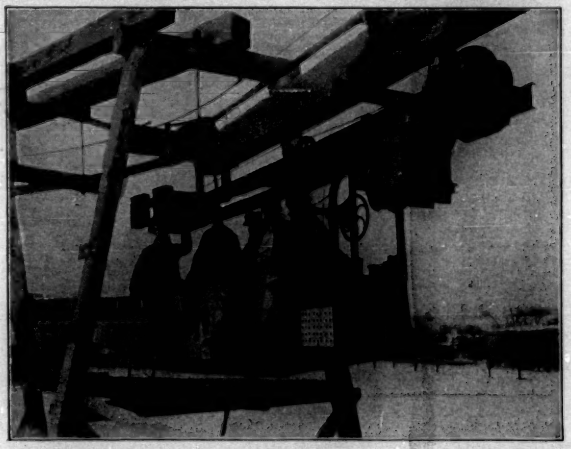


The long detour in crossing between the mill and storehouse is avoided.

ers, if an equally careful surveillance had been exercised in indoor and out-of-door economics.

Fifty cases of the same weight could have been transported between the same discharging and receiving points, the energy employed being a telpher outfit, a telpherman and a helper, and the entire cost, reckoning interest on plant, depreciation, power and wages, would be less than $1. I would like some mathematician to figure the loss in capital energy by reason of the cited carelessness on the transportation side of production.

It is no exaggeration to claim that there is not a manufacturing plant in operation which could not materially reduce cost of production if the usual carefulness of detail was extended to the transportation end. It may be, however, no fault of the manager that this is so. A manager is busy enough in caring for phases of the business which are continually demanding his attention, and he may be excused if the knowledge has not come to him that in the past five years an entirely new significance has been given



The load, with the five men, lifted 50 feet and conveyed 1,000 feet, showing massiveness of construction of the conveying and hoisting machinery, method of electrical control and brake wheel.

to the term, local transportation, by the strides of progress made in the science of telpherage.

If you have ever been in a large dressed-meat establishment, you have seen one man push a huge carcass of 1,200 pounds with one hand. In no other method of traction could that same task be performed; still there are disadvantages in that system. The stress is so applied as to produce unnatural resultants; consequently, an abnormal

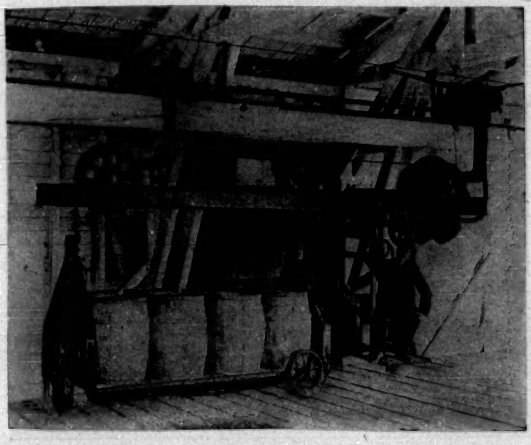
leverage and friction, when comparing the weight movement with that as applied in operating telpherage.

In telpherage the motive energy is directly applied to the frictional points. The bearings of telpher, trailer and hoist are encased in oil or grease, and the material weight is divided, the load supporting downcomes being centered in accordance with the requirements of the problem. We thus

Full bucket starting up the grade. Empty bucket being filled. Light steel trestle, long span. The track is T-rail upon stringer. The coal can be taken either from pits between or at the side of the tracks, either by the self-dumping buckets, as shown in the photograph, or by means of the clam-shell buckets.

see that in telpherage we have a system in which is discounted the advantages peculiar to the hitherto supposed most efficient method of weight movement. Out of doors the telpher track may be constructed of solid steel or of steel cable, the latter being invariably used in long spans over canals, river gulleys, railway tracks, or when the line is to run at an altitude of 50 to 100 feet. Under such latter conditions the running cable track is supported between posts by

C-shaped wrought-iron hangers, which have an upper grasp on a stout suspension cable and a lower clutch on a 3-foot beveled shield into which the running cable is sunk. The tightening of the suspension cable not only prevents excessive sagging of the running cable under a load, but maintains it at a slight elevation, so that when the telpher crosses the shields, the track is level. In all cable installations the spans, which are nominally 50 feet, have this simple



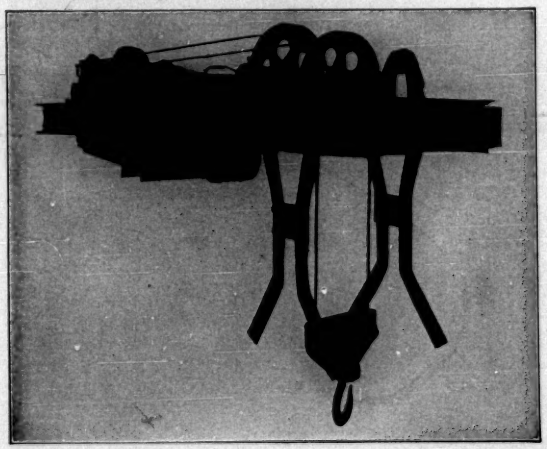
Track adjustable so as to be easily leveled. Suspended from the cross timbers. One man does the work of moving tons up any incline to a vertical by the hoist, any horizontal distance or up-grades by the telpher, by merely turning the electric switch.

suspension, but over rivers, double, triple and even quadruple suspensions are required, the necessary suspension dip being secured from high structural steel towers at either side of the depression.

The telpher, or locomotive, is of the simplest construction. In concentrated conveying, or where the load is suspended from one point, as in coal carrying, a follow wheel is affixed to the telpher frame to prevent excessive pendent acuteness,

while for distributed loads a two-wheeled trailer is attached to the telpher by a connecing rod. Invariably the trailer is used where a telpherman operates the machine. The trolley wire is above the track, but inside buildings this wire may run alongside, inclosed in a conduit, thus absolutely insuring safety against conflagration. The track for inside work is solid steel supported every 15 to 25 feet.

Here we have a machine showing a telpher with its



Details of one of the more massive hoists with exceptionally large drums and sheaves for high speed.

trolley poles, the trailer, and a two-sheave hoist. The controlling devices are directly at the telpherman's hand, the whole consisting of apparatus for enormous freight-bearing as simple to control as is a street car—in fact, more simple, for the telpherman is taught his work in three days without trouble. The primary cause for exceptional compatibility between machine and power rests in the fact that there is less frictional resistance in the former than has before ever been attained in a heavy-weight bearing vehicle.

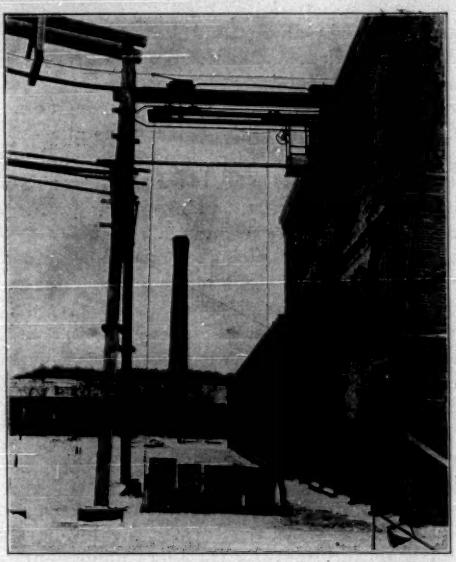
The hoist used in telpherage is a beautiful piece of machinery. It is composed of a double gear, a worm and drum and in its position on the telpher frame comes as near to being a direct-connected appliance as anything on the market, consequently the percentage of efficiency which gets to the load is remarkably high.

A gas engine, consuming but a few cents' worth of fuel per hour, and a direct-connected generator represent the minimum of power cost up to a 12-horse power requirement, and such an engine and generator will considerably more than suffice for all but extraordinary installations of telpherage. In those methods of conveying where each unit or combination of units to be moved is dependent on the stationary engine and drum, the producing qualities of the conveyor bear no sort of economic relationship with the productive force. The stationary machinery must be employed unintermittently to be ready at any time to take on a load. In telpherage this principle does not apply. As the several conveying units are independent, that is, as each conveying unit is under its own power, its effort of power consumption is relieved from the line immediately it becomes non productive. The computation of actual horse-power hours, therefore, as applied to telpherage is a subject which even the electrical engineer may study with profit when considering freight handling.

Telpherage is of three types—non-automatic, semi-automatic and automatic. In the former the telpherman rides on his machine and controls its every movement. Where his several distributing points are all over a plant, and it would be expensive to maintain a tender to care for his receipts and deliveries at each point served, the telpherman may be his own loader and unloader, as well as hoister, conveyor and depositor.

This very interesting telpherage installation has been made in a cotton plant in New England, and transports cases of goods between two buildings 1,200 feet apart. A pendent attachment permits the telpherman to lower himself 40 feet; consequently, with trap-doors in floors he may personally attend to all loading and unloading on the differ-

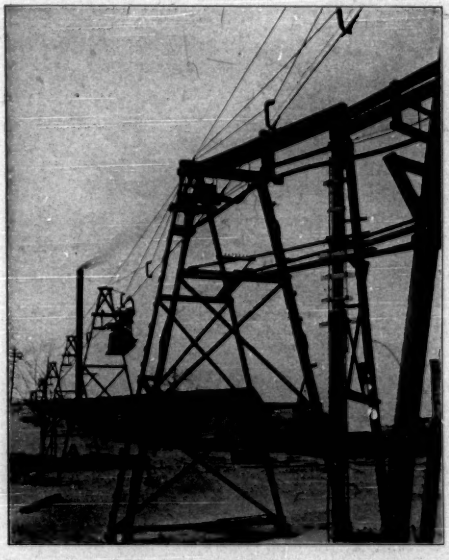
ent floors of the mills he enters; or, if he is out of doors, he makes landings on projecting platforms at each floor of a building, from which place the goods can be easily hauled into the room, the platforms, or telpher carriers being on trucks.



The operator, by pulling a cord, raises himself as well as the load, and then conveys the load to its destination. As well as the telpher, the hoist can also be controlled from the cab. One man can, therefore, attend to attaching and detaching the truck, raising and lowering the load, as well as the conveying. The machinery not only conveys, but also is equivalent to a movable freight elevator.

Before telpherage became a part of this manufacturing plant three teams were kept constantly employed in this transportation, two men attending each team. The cases were trucked from a store by hand, loaded onto the team and later unloaded onto the ground floor of a mill, where they

were elevated to the upper floor. A round-trip occupied twenty minutes. To-day the telpherman lowers himself through the roof of the receiving house to a position near where the goods are packed, personally loads his platform, or carrier, raises himself and load to his telpher by his hoist



It is often necessary to convey from one group of buildings to another over railroad tracks or traveled roads or hills, and in winter above the snowdrifts This picture shows such a line in operation. Also an elevated track switch, where the line diverges. The track may be cable, T-rail upon stringer, or T-rail upon steel girder. Any reasonable load and speed of hoisting and conveying.

pendant, swings himself into his seat and in one minute is at the other end of the line, entering the second story, where he also serves the first by his self-lowering attachment.

This operator makes a round trip in five minutes, accomplishing with his telpher apparatus the entire work formerly occupying the time of six men and four horses.

The semi-automatic line as shown in this picture is controlled by a man whose position is in the small house on the trestle. When the bucket is filled, the operator, who over-

Height of track, 50 feet; load, 2,000 pounds; speed of hoisting, 60 feet per minute; capacity, 200 tons. Operation: Upon closing the switch the coal is elevated, conveyed to any location in the yard, automatically dumped, and the telpher returns the empty bucket for another load. Electricity does the work. Projecting track may be used over boats as well as over railroad tracks.

looks all parts of his problem, throws on his hoist switch, and when the proper height has been attained the telpher switch is opened and the machine runs down the line.

If desired, this installation may be automatic after hoisting is accomplished, the starting of the telpher being done by the opening of the switch by the hoist clutch contact, and the reversing of telpher movement being automatically

performed at the end of the line. In this semi-automatic installation, rapid handling is required. The operator in his tower stops the telpher immediately at any point, and, with an automatic device for dumping, the load is deposited at that point.

This installation shows three distinct economic propositions, viz., a nominal fixed charge in proportion to work performed, the effect of constant and rapid handling of coal on the vexing question of demurrage, and an unprecedented economy of storage space.

In the automatic installation are many interesting problems. Almost any height may be served by such an outfit, and the expensive old-time method of lowering and raising by elevator is entirely obviated. A large wood-working establishment receiving two cars of small worked wood daily, employed lumpers to back the material in baskets from the car up a flight of stairs, across a yard and into a workshop. It did not occur to the management that this was an expensive method of handling, although ten men were engaged in the operation. Perhaps the management were philanthropists, and wanted to keep those men employed; but we live in an age of competition; we are forced to be selfish, and in this case that very selfishness resulted in a humanity far exceeding the efforts of the management.

It became necessary to treat the material at the factory, where before it had arrived treated, and in the new arrangement the material had to be carried to the roof of a building and dropped into bins. This meant an increase in the lumpers from ten to eighteen; and although the men received but $1.50 per day, each, eighteen of such chaps cost money to maintain.

Telpherage was installed. One man filled a bucket with the material, threw on the hoist switch, then went to work filling another bucket. The electric hoist raised the load to the required height, the telpher switch was opened automatically, and the machine departed on its way. The run across the yard was made at 40 feet in the air. An automatic tripper was set at a special bin among the twelve

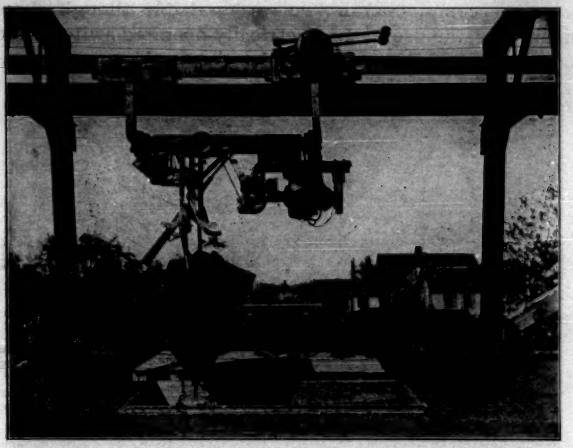
bins, the load was automatically dumped into the desired bin, and the machine arrived back to the starting point just as the second bucket was filled and ready for transport.

The installation caused much unfavorable comment from the lumpers, but it reverted to their good. When no longer able to do their habitual work, they cast about for something else to do, and all but two of the ten found more re-

Where there are heavy grades, the double telpher is used; that is, the trailer is replaced by telpher the same as a motor is placed upon both the front and rear axles of an electric street-car. Steep grades are easily surmounted. Both telphers are operated by the telpherman from his seat by the cylinder magnetic blowout controller. The full load is now passing from the cars to the hopper above the boilers

munerative labor on more important work in the same establishment. They could have done this new work before, but having a job they did not think it worth while to better themselves. Indeed, I understand that one of those former lumpers has so far advanced his condition that he is now running for alderman in the city where the plant is established. If he wins out he may place the entire credit to

telpherage. The two exceptions to an improved social status from this installation got work in another factory as lumpers. You know that lumpers we will have with us always. Over buildings, around corners, across rivers, sometimes bracketed to the sides of buildings, at other times supported in the open land by A bents; using the less val-

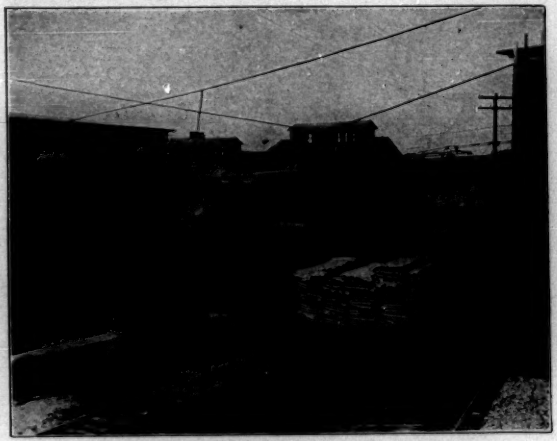


The single-motor telpher, the trailer, the swinging downcomes, the electric hoist, minimum headroom, one sheave type and the automatic control. By moving a single switch, located at any convenient point, the telpher is started, stopped and reversed, and the same is also true of the raising and lowering by means of the electric hoist; all that the operator has to do is to move the switch. At the end of the line, dead sections stop or reverse the telpher. Such lines, with the electric hoist, are independent of distances and curves. The opening in the roof of coal shed is uncovered for receiving the coal.

uable ledge for its "way;" running onto branch tracks by switches which the telpherman himself operates, opening and closing doors; running the entire length of storehouses and picking up a load without a particle of previous preparation—such is telpherage. In-and-out handling, it is the same to telpherage, whether the distance is 50 feet or

1,000; whether the haul is back and forth between different departments, or over the full length of the line, in whatsoever work it is employed, the effect is the same. Supplying the most effective mechanism for the action of the most inexpensive motive force the world has ever known, cost of transportation is decreased.

Automatic control of telpherage from any convenient point is accomplished in a very remarkable though simple manner by the use of an electrically-operated switch which has been called into existence by the requirements of tel-



Paper pulp from one mill to another during process of manufacture. Automatic line with electric hoist.

pherage. By this attachment, working in conjunction with an ordinary controller, the direction of travel of either telpher or electric hoist may be changed, or the speed may be regulated, by the movement of a single controller handle. Telpher or hoist may be started, stopped, reversed or speed regulated wherever the machine may be on the line, although the operator is at his controller at some fixed point, or, if desired, the operator may start the machine, leaving it to its

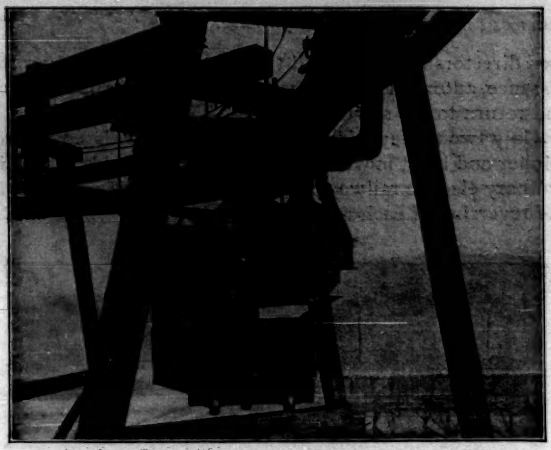
own directorship, and it will traverse the line, whatever the distance, automatically deposit its load, reverse its direction and return to the starting point.

Only two trolley wires are employed in this control of telpher and hoist movement. When one considers that in ordinary electric railway practice four wires are necessary in the reversing of each motor, independently, it will again be

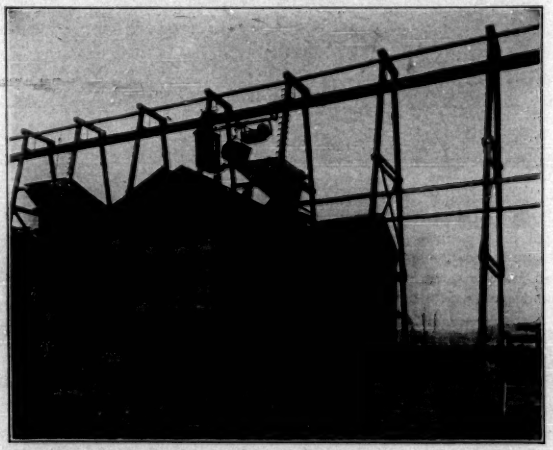
Taking freight from or lowering to the side ports of a steamboat. In unloading, the material is raised and then conveyed any reasonable distance. Load, 6,000 pounds; speed of hoisting, 60 feet; speed of travel, 1,000 feet per minute. Independent of fall of tide. Track can be extended so as to take load directly to or from barges or floats. In one telpherage installation one man replaces sixteen.

seen that telpherage is an unequalled vehicle for the action of electric energy.

Concerning strictly the method of hoist operation, and especially in semi-automatic installations, each machine is supplied with a small cylinder switch, which is manipulated by a solenoid working against a spring. Suppose the load is about to be lifted. By infusing power through a station-



Telpher, hoist, bucket and enclosed cab upon a curve. Large drum, minimum headroom hoist Electricity can as easily hoist and transport six tons as one.



Gas works' telpherage. Applied to the hoisting, conveying, screening, depositing and storing of coal and coke and the removal of ashes. Also the quenching of coke and the transporting of the same to cars or wagons for shipment.

ary switch located at any point of the line, the solenoid of the automatic switch is energized and puts a tension on a spring. When the solenoid is de-energized the spring is released and rotates a cylinder which changes the various connections, thus reversing the motor.

It will thus be seen that with each cut out of power, there is a reverse of the hoist motor. The same principle is employed in the control of telphers in semi-automatic lines.

Clam-shell bucket, with double-drum electric hoist. The bucket is lowered open upon the coal or like divisible material, "grabs" the same, and the electric hoist closes the bucket and elevates the load, while the telpher does the conveying. Telpher upon a curve works equally well upon a grade. Load, with bucket, 3 tons. Speed, 1,000 feet per minute. Electricity does the work of eighteen men, one man directing.

A most important feature of this arrangement is that all breaking of the current is done at the stationary controller and never at the cylinder switch on the hoist, consequently there can be no arcing at the latter point.

If, when raising the load, the operator cuts off the power, the load stops where it is. Should he wish to go higher, he, having reversed the hoist movement in the cut-off, simply

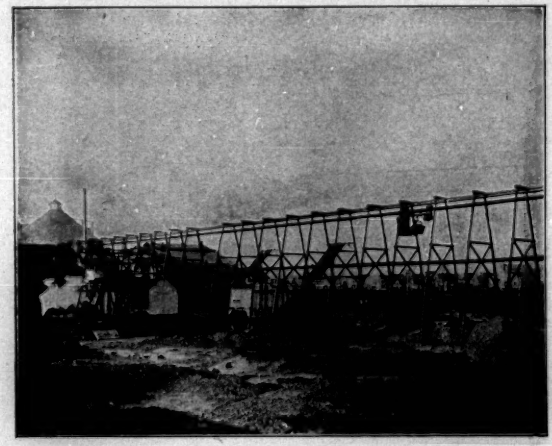
puts on power for a second, then again cuts off. The motor is now again reversed and with the next infusion of power the load elevating is continued. There are, therefore, but two trolley wires used in theentire operation, and no ground return. The same method of control is used for the telpher.

Large capacity coal or ash bucket, bottom dumping for small headroom. Bucket can be lowered 50 feet. Telpherman located most conveniently in the center.

A 10 horse-power gas engine is furnishing electric power for the lifting of a 3,000-pound telpherage load at a speed of 60 feet per minute, and a horizontal run at a rate of 1,000 feet per minute, at an expense of 30 pounds of coal per lifting horse-power hour, and 12 pounds for the horizontal horse-power hour. During a recent test of eight and one-half hours' continual running in a ten-hour day, one-twelfth

of the time was occupied in the lift, ten-twelfths in the horizontal run and a twelfth was lost in the changing of loads. The average per hour consumption of coal in the horse-power working hours involved in the problem was $13\frac{7}{10}$ pounds, or an actual power expense of 30 cents for the day's work.

Telpherage is an innovation, but it has come to stay. The progressive president of a large illuminating plant once expressed a thorough knowledge of what was needed to

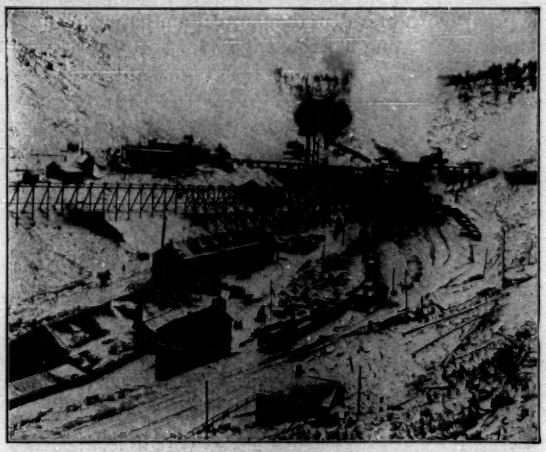


Telpher in gas works.

satisfy his requirements; "but," he continued, "I have heard of no apparatus on the market which will enable me to bring my several planes of operation into a comprehensive, and at the same time economical grasp. I not only need a conveyor, but one which will handle anything, anywhere, in a height of 50 feet."

Later, the gentleman found all necessities supplied in telpherage, through an installation of which he has practically doubled the efficiency of his plant. His coal-gas

retorts, water-gas retorts, screens, crushers, ash dump and coke store, although the individual serving-points vary in location from planes 9 feet below to 40 feet above ground, have been connected for handling, so as to produce of the whole an economic problem as simple as any feature in his actual manufacture.



A long trestle upon the hillside for conveying a long distance not only coal and ashes, but any other products. This line is not only interesting on account of its length, but on account of the peculiar construction of the bents or supports, they being placed upon a steep incline.

It would be impossible to accurately compute the profit derived from his installation. The reduction in money expense is but a minor part, though twenty-five men and four horses would not accomplish the work done by the machine in its day and night shifts. From quenches 6 feet below ground 1,400 pounds of coke are delivered to the charging holes of the water-gas retort 40 feet above ground, the operation consuming but three minutes, though the effected points are 400 feet apart and two right angle curves intervene. Duties are performed by telpherage, which pre-

vious to the installation had no existence, but which, having been made possible, tend to produce that result in the yearly balance sheet which all live managers and presidents are striving for.

The practical value of telpherage has been so thoroughly demonstrated that you electricians who have to do with traction will surely hear more of it than has been explained

A ton of coal just before being dumped into the steel hoppers. The coal is hoisted from the cars by the portable electric hoist shown in the foreground of the picture, telphered 1,coo feet up a steep grade and around curves, to be placed in the hoppers elevated above the boilers. The empty bucket is then returned for one filled. Electricity does the work. One man only is necessary.

to-night. Obviously, telpherage could not have reached its present stage of perfection with other than electric power, but, to return the compliment, no other mechanical device has been created which so splendidly attests to the subtlety of the unseeable motor force. Three distinct operations hitherto considered subjects for separate mechanical treatment have been joined in a system, whose machinery pre-

sents a compactness of design, an enormity of efficiency and an economy of operation which is unequalled among transportation devices.

In addition to the lines as shown there is also what is called a moving telpher track. This is a section of track which is placed between the two side tracks, something the same way almost as a crane, with the exception that the telpher passes upon the side rails and across this movable tract to the other side. In the handling of miscellaneous freight by means of this moving track, goods can be lowered or raised from any portion of the floor or yard, and this is done without switches and without a multiplicity of tracks. The technical term for this is movable telpher track or space-covering track.

THE GROWTH OF THE SOFT COAL INDUSTRY.

To show what an immense figure the soft coal tonnage has reached one has but to regard some recent figures. The production of bituminous coal in the United States last year was 285,000,000 net tons, an increase over 1899, five years ago, of 94,000,000 tons, and an increase over 1893 of 155,000,000 tons, or much over 100 per cent. The present year will probably show a falling off, but not nearly so much as some people think. Certain it is that the tonnage of the soft coal carriers as yet shows no material decrease as compared with the corresponding period of last year. The tonnages are always about a month in arrears, and the reports for the month ending June 30th and the year to that date will show some falling off, but we shall be surprised if the total for the year 1904 shows less than 270,000,000 tons of soft coal produced. That is a reduction of 5 per cent. from last year's figures. The per capita consumption of coal shows an increase as steady as the growth of civilization, and will not cease until inventors cease from their labors and machines are discarded in favor of a return to hand-work. Even in coal mining itself there is a marked increase in the use of machinery in and about the mines, and the coal used for colliery consumption is larger every year, though the result of this innovation is a reduced cost of operation, and in some cases better prepared coal.

In 1880 the production of bituminous coal per capita was about ¾ ton, while in 1903 it was about 3½ tons per capita, and even should there be no greater increase in per capita consumption during the next ten years, the production by 1914 will be not less than 350,000,000 tons, as the population of our country at that time will be at least 100,000,000. But the accelerating rate of growth and the enormous expansion of our industrial development, the wonder of the world, give reasonable ground for believing that ten years hence the United States will be mining much beyond 400,000,000 tons, and possibly not far from 500,000,000 tons a year.—*Iron Age.*

Mining and Metallurgical Section.

Stated Meeting, held Thursday, April 21, 1904.

The Copper River Country, Alaska.

By W. R. Abercrombie, Major U. S. A.

General Introduction: Alaska was discovered a little over a century ago by Russian fur hunters. Sailing east from the coast of Siberia they first came upon the islands of the Aleutian Archipelago, which they took possession of in the name of the Czar of all the Russias.

Having established themselves on these islands, and having thoroughly subjugated and partially christianized the docile natives, they pushed farther east, found and explored the extensive coast of the mainland, and after many hard fights with the warlike tribes of those regions, established ports on Behring Sea and the North Pacific. The Russian Government granted to those early adventurers special privileges in this territory which they had discovered for the Crown. Thus was the foundation laid for the famous Russian-American Company that held almost undisputed sway over Alaska until it was purchased by the United States in 1867, through the foresight, diplomacy and wisdom of Hon. William H. Seward, then Secretary of State.

Under the suffrage of the Emperor of Russia the company named enjoyed positive power and ruled the country with a rod of iron. Not only did it have absolute right over territory, but over everything except the unexplored region of the far interior and the many tribes of free savages therein, who recognized no master. Nothing was made public except such affairs connected with the fur trade as the company saw fit to permit to be published; hence, when Russian America became a portion of these United States little or nothing was known of the interior, and from 1867 to 1869 nothing of particular importance enlarged our geographical knowledge of this newly acquired

territory. On the sixth day of April, 1869, Captain Raymond, Corps of Engineers, U. S. A., and party left San Francisco, Cal., on the brig "Commodore," on the deck of which was a 50-foot stern-wheel steamer, "The Yukon," bound for St. Michael, mouth of the mighty Yukon River, the waters of which this small craft was to be the pioneer in navigating. On the 26th of June, 1869, this party, after an uneventful voyage via Sitka, arrived at St. Michael, and on July 1st steamed forth to ascend the Yukon, 1,040 miles. Thirty days later Captain Raymond and party arrived at Fort Yukon, terminating successfully the first journey by steam on the Yukon River.

The object of Captain Raymond's mission to Fort Yukon, the most northwesterly station of the Hudson Bay Company, was to determine astronomically the geographical position of that station relative to its location in our newly acquired territory, and from that time to 1883, fourteen years, no one appears to have been disposed to undergo the hardships incident to the exploration of this great unknown region.

On the 22d of May, 1883, we find a hardy band of explorers headed by First Lieutenant Frederick Schwatka, Third U. S. Cavalry, A. D. C., who had previously made extensive explorations into the Arctic from the Atlantic Coast, sailing from Vancouver Barracks, for the head-waters of the Lynn Canal, a long, narrow fjord terminating in the Chilcoot Inlet, Southwestern Alaska. The Raymond expedition of 1869 developed the fact that to ascend the Yukon it would take about the entire season to fight the swift current; and after a careful study of the geographical features of the drainage of the head-waters of the Yukon, Lieutenant Schwatka conceived the idea of crossing the portage through the Chilcoot Pass, from the head of the Lynn Canal to Lake Lindeman, a tributary to the Yukon, and going down stream with the current through the Yukon Valley to St. Michael. On the 10th of June, 1883, the Schwatka party, having disembarked at Chilcoot, started, together with a number of Chilcoot Indians as cargo carriers, up over this now famous Chilcoot Pass;

arriving at Lake Lindeman, the Indians returned to their country, leaving the white men to pursue their journey. In due time this party landed at the mouth of the Yukon, performing successfully one of the most remarkable raft journeys on record.

The exploration and mapping of the Yukon Valley disclosed the relative position and course of this river to the trend of the Pacific Coast line from Lynn Canal to Cook Inlet to be parallel. A glance at the map of Alaska will show a continuous curvature to the westward. It will also be observed that from the summit of Chilcoot Pass to Mount St. Elias, the eastern slope of those mountains are a portion of the Northwest territory, a province of Canada; so that while the Schwatka exploration developed the Chilcoot Pass as a passable route for the American miner and trader to journey into the Yukon Valley, it also developed the fact that from the crossing of the summit of the Chilcoot to the intersection of the national boundary line with the Yukon River at Eagle City, more than 400 miles of the Yukon Valley lay in foreign territory. The question then arose, where should we find an "all-American route?" It was at this period of the development of the geographical features of Alaska that I became identified with the exploration of that country, covering a period of some sixteen years.

The result of many conferences relative to the possible discovery and location of a route from the seaboard to the interior of Alaska through American territory, which would be free from ice and available for the traveler all the year round, resulted in my exploration of 1884, the object of which was to explore and survey the Copper River Valley to the Yukon drainage.

THE 1884 EXPLORATION OF THE COPPER RIVER DELTA AND PORT VALDEZ.

On June 1, 1884, I left Portland, Ore., with my party, which consisted of four assistants, on the steamer "Idaho," James Carroll, Captain; the understanding being that the steamer would take my party some 50 to 60 miles

up the Copper River, where we were to disembark. At the date above mentioned little or nothing was known of the interior of Alaska, and I was instructed to confine my explorations to the Copper River Valley, to ascertain the number, character and disposition of the various tribes of Indians, the feeling which existed among them towards the white man, their mode of life, means of communication with the outside world, and what had been their attitude toward the Russian Government in the past. I was to note the geographical features, mineral and agricultural resources and the various kinds of fish and game existing in that country; in fact, to collect general information. Steaming down the Columbia River, we passed out into the Pacific and laid our course for the Straits of Fuca, through which we passed to Victoria, then the principal town in British Columbia. Leaving this quaint old place, we steamed northward through the inland passage to Sitka, Alaska, at which point we expected to get a Russian pilot to guide the steamer up the Copper River; having secured a Russian half-caste, who claimed to have the necessary knowledge, we left the beautiful harbor of Sitka, and steaming north on the morning of June 16th, my party arrived at Nuchek, a trading station of the Russian-American Company on Hinchenbrook Island. Our pilot informed us that this was the place known to the Russian traders as the Copper River country, and after interviewing the agent in charge of the station, we learned that we were on an island about 60 miles from the mouth of the Copper River, but just where it was he did not know, but I could undoubtedly get Indians to guide my party to it. In the meantime, our outfit having been landed on the beach, we stood with some 80 to 100 natives watching the steamer "Idaho" steam south to civilization, the white man's country, and the situation was not pleasant. As this was the first steamer to visit this section, it was curious to note the effect on the natives, who thought it was some sort of a whale that the white man had captured and made a slave; and, as we watched, a parting salute was fired, as was the custom in those days, and all the natives ran into their village and hid in their huts from evil

spirits. One word as to the history of this village, which was discovered by Cook between 1776 and 1779. In 1778 the Russians built a log fort as a trading station. In 1796 two expeditions were outfitted at this point to explore the Copper River Valley, but both failed. Other Russians followed without success, and in 1847 Rufus Serebevinkoff, a half-breed and a graduate of a school of commercial navigation of St. Petersburg, Russia, explored the Copper River Valley, and was probably murdered by a chief of the Chettyna Indians, as his notebook was afterwards given up by the coast Indians who got it from the Copper River natives.

With the history of these failures before me, I, on the day following the landing of my party, gave a "potlatch" to the natives in accordance with their custom, which is about the same thing as giving a political dinner with us. At this feast I made known my mission largely by signs, and engaged some of the natives with their boats to assist us to reach the Copper River. These arrangements consumed almost the entire day. As the white men were not familiar with the baiddirra, a native boat which consists of a birch frame over which is tightly drawn a covering of sealskin, I purchased an old Russian boat for myself and assistants, and with this equipment of sea-going craft, I left Nuchek on the morning of June 20, 1884, coasting along the shore of Hinchenbrook Island to the north and west into Prince William Sound to Point Johnson. The water was very clear, the bottom being plainly seen at 25 feet. Passing through a narrow channel between Hinchenbrook and Hawkins Islands, my party camped on a small island close to the mainland. With an early start next morning, to take advantage of the tide, we pushed on in the direction indicated by our Indian friends. Toward the mouth of the Copper River, I noticed that the water was not so clear, nor was there any seal or fish to be seen. During the afternoon our Indians seemed much excited, until finally our Russian ship's boat, which drew probably 18 inches of water, grounded, notwithstanding the fact that we were some two or three miles from land. One of our party got out of our

boat to sound with a pole for deep water, as the color of the ocean had now changed to milky gray. Being intent on watching his movements, we were greatly surprised on looking out seaward to see mud flats for miles.

After some hours sign-talking with the Indians, I learned that we had arrived at the mud flats at the mouth of the Copper River at low tide and that we must wait for the flood tide to enter the river itself. In the evening we drifted up with the incoming tide into one of the numerous sloughs which compose the mouth of the Copper River, and camped near an Indian village of six or seven barraboras or houses, each house being occupied by from ten to fifty natives, all of whom turned out to greet us, much to the dismay of our island natives who represented these Copper River natives as a ferocious lot who had killed all the Russians that had ever come within their reach; and from the lively manner in which they paddled out to sea, I imagine they thought the American would fare no better. The first thing to be settled was the "potlatch" which the head men of the village decided in conference would be the next afternoon, the natives giving an entertainment in honor of the white chief in the morning. Accordingly, about 10 A.M. the next day, three of the old men paddled over in their canoes to escort us to their entertainment. As everything in the eating line is most dear to the native, I decided to go to the reception alone and leave my assistants to watch the provisions. After many explanations, this was agreed to by the old chief in a half-hearted way. Getting into a canoe I paddled over to the largest house, which was about 40 feet square, on the four sides of which were built a series of cells with doors. On top of these cells lived the men, while the women and children lived below. The entrance was through a hole about 2 feet in diameter, over which hung a skin of some animal; the only light came from an aperture in the roof, which also allowed the smoke from the fire to escape. I suppose there were over a hundred people in this house; the stench was of a quality not to be forgotten. In front of the door of this barrabora was left space enough for one native to enter and dance to the music made by some eight or ten who chanted

in that dismal monotone peculiar to natives the world over. The characters impersonated were the bear, moose, fox, sea otter and whale, etc., with some portion of the animal, usually the skin, used as a decoration for the actor who would chant of his prowess. During the impersonation of a whale, on the day in question, the native told how he came out of the Arctic Ocean, where darkness prevails from October to May, to a village of the island natives, where a mighty chief had a strong box in which he kept the sun, moon and stars. This chief had an only son, whom he loved dearly. The whale became acquainted with this boy during a storm when the boy was out on the ocean in a kyac, sea-otter hunting. The whale learned from the fox, who knows everything, as he is constantly nosing about, that the chief was away in his big war canoe, so he swam into the bay where the boy lived and called to him to come and get on his back and take a ride. He gave the boy a short ride and came back. The boy urged the whale to continue, as he had never ridden so fast before; the whale refused, but agreed to after a while if the boy would let him see the box of light. The boy called to a squaw to come down to the beach and hold up the box so the whale could see it; when she did so, the whale rose out of the water, thereby creating a mighty wave, which ran up the beach with such force that it threw the woman down. As she fell she dropped the box on a stone and broke it open, when the sun, moon and stars escaped and ran up into the sky never to return. For this act the whale was turned into a great chief with many dogs and big canoes as a reward for his service to mankind in establishing the sun by day and the moon and stars by night.

In the afternoon all the natives came to my camp, where we gave them probably their first taste of civilization, consisting of crackers and bacon. After the "potlatch" a general council was held. I explained to the natives that we wished to ascend the Copper River and wanted them to help us, and that we would pay them in provisions. We had no difficulty in arriving at an agreement whereby they were to serve us. On their part the old chief explained that

the Copper River was a very dangerous body of water, and that many Russians had been killed in attempting to ascend it, and that their people had often been held responsible for their death; whereas, as a matter of fact, the river had swallowed them up. To show the simplicity of these people, while we were having our conference my topographical assistant was working up the latitude and longitude by means of an artificial horizon, which consists of a tank of quicksilver enclosed by two heavy plate-glass windows, being about 4 by 8 inches. One of the natives, accidentally looking into the artificial horizon, saw the image of the sun, which created great excitement, following, as it did, the story told in the morning entertainment of the box of light. This instance was taken advantage of to assure the natives that we had provided against all accidents from drowning in the Copper River. This was followed by a present of a blanket to each chief, when the council was closed by the natives agreeing to start early next morning. We broke camp at sunrise, our transportation consisting of the Russian boat and some fifteen or twenty little canoes. Passing up on the slough for some 8 miles, we came to within a mile and a half of the mountains forming the western side of the Copper River delta. From this point we cut a trail to the mountain through the heavy growth of alder brush, and climbing up the base some 500 or 600 feet, we obtained an excellent view of the Copper River delta, which, at this point, was some 30 miles broad, and consisted of a series of small streams and sand-bars as far as the eye could reach. Our discovery was anything but satisfactory; where we had expected to ascend the Copper River for some 70 or 80 miles in a steamer drawing 18 feet of water, we found that it would be necessary to proceed with the lightest-draft canoes for some 90 miles to reach the head of this delta, where the Copper River Valley proper would begin.

Having worked our way some 15 miles farther up stream, we encountered a new feature, a new obstacle to our navigation. Small pieces of ice were constantly being met with, and on the afternoon of the 14th of July we were forced to land and pull our canoes out of the river to allow the ice

floe to pass by. Early on the morning of the 15th we broke camp and continued our journey, our progress being very slow, owing to the constant passage of ice down the river. During the afternoon of this day, one of the small canoes belonging to the natives was crushed in the ice, and the poor fellow drowned, while our larger boat was carried some miles down stream. From this on it became a constant fight. At times our canoes would have to be beached and drawn for half a mile or so over the sand-bars to other streams, in crossing one of which another native was drowned, when the remaining thirty or forty absolutely refused to proceed farther until the water had fallen.

From July 16th to 19th it rained almost constantly; the river was many times blocked with icebergs, rendering navigation impossible. On the night of July 21st I witnessed a most interesting spectacle; first large bergs came sailing majestically down-stream, passing and repassing each other as the water forced them from one side of the river to the other. On many of them were large bowlders that looked not unlike passengers. These would occasionally tilt in striking a sand-bar so as to throw the bowlders into the river. Then, again, two large bergs would come together with a shock that would make the ground tremble. This, taken together with the roar of the water, had a tendency to make us a little timid in the handling of our boat. This continued until the 31st of July, when for some reason the ice floe in the river ceased.

In the afternoon of this day a bidarra loaded with furs and manned by ten upper-river natives came down the river. Seeing our flag, they landed and were very much surprised to find that we were white. After some hours' sign-talk we made them understand that we wished to go up into their country and to be their friends. With a liberal allowance of black tea, of which they are very fond, we talked the matter over, and they agreed to take their furs on down to the coast tribe, do their trading and return and assist us. Later on these natives returned with a few of the coast Indians with them.

Having cut a trail to the Miles Glacier, we started out

with the intention of making a portage over that ice field, landing our canoes above rough water. But after traveling some 12 miles over this glacier, it became so cut up with crevasses that we were forced to return. The head of the Copper River delta was originally blocked by the Childs Glacier coming in from the west and the Miles Glacier coming in from the east. These glaciers, in their earlier stage, brought down with them immense masses of moraine, over which the river ran until the current carried the bowlders and silt off faster than nature could deposit it, then the water cut through the ice, and at the period when we were there had left the face of the Miles Glacier some five or six miles long and the Childs some three miles long. The ice floes that we had met with during the summer were occasioned by the river digging the gravel and bowlders out from under the faces of these glaciers, which would average between 300 and 400 feet high, when a portion or the whole face of the glacier would fall forward into the river with a shock and detonation that could be felt and heard for over 20 miles. I have seen the river bed below Childs Glacier almost entirely bare, when, with a roar and grinding noise almost indescribable, the flood of water and ice would come rushing down stream, grinding up everything before it. It was in these ice jams, the Indians claimed, that most of the Russians had met their death. To avoid these, it would be necessary to travel over both the Miles and the Childs Glaciers, which our efforts had proved to be impossible.

Returning to the point of the river just below Miles Glacier, we waited a favorable opportunity between the ice gorges and crossed over to the left-hand side with the upper river natives, and hauled our boats some 8 miles up-stream to what is known as the "Abercrombie" Rapids. This is a seething whirlpool some 3 miles long, the Miles Glacier having backed the river up. It now became evident that as a route of travel from the coast to the interior, the mouth of the Copper River was valueless.

Looking down toward the sea on the 1st of September, we could see miles upon miles of sand-bars separated by

small streams, into which the Copper River divided itself after leaving Childs Glacier. Through this network of small streams it had taken us three weary months to cover a distance of 90 miles.

By this time we were somewhat stiffened by exposure to rain and wading in the cold, icy water, and considering it wise to return to the coast, we waited a favorable opportunity to run by the glaciers. So on the morning of September 1st we shot by the face of Miles Glacier without accident, and, landing our topographical assistant with his field notes, we ran down by the face of Childs Glacier. The sensation in passing the mighty walls of ice was sickening; the current was so swift, some 6 or 8 knots an hour, that by looking at the shore we apparently flew, yet while looking at the glacier we appeared to be standing still.

Passing by this mass of ice we arrived in our former camping place in ample time to regain our old Russian boat and re-embark with our topographer ahead of the ice floes.

On the following day we arrived at Alhanic, having covered in two days down-stream the distance that it had taken us three months to travel up-stream.

Leaving the mouth of the Copper River the following day, we proceeded to our old camp on Hinchenbrook Island, where we arrived on the 10th of September after encountering some heavy storms in Prince William Sound.

From a half-breed Russian, who had been in the employ of the Russian-American Company, I learned that there was a Russian at Port Fidalgo, a tributary to Prince William Sound and some 70 miles from Nuchek, that could probably give me some information of a route from Port Valdez to the Copper River. So on the 11th of September, I left Etches in a canoe with four natives, and the following day arrived at the barrabora of one Plutoniff, a Russian exile, from whom I learned that prior to 1868 the Copper River natives came down to the head of Port Valdez through some pass in the mountains to trade their furs; but during that year the smallpox had broken out among the coast Indians, which had swept away the entire village at the head of Port Valdez.

Plutoniff did not know where the pass was, nor did his sons. However, by persuasion and the use of considerable black tea, I induced the old man to send his sons with me to the head of Port Valdez in the hope that I might there find more information.

Proceeding from Port Fidalgo to Port Valdez, I entered and explored the upper end of that "Fiord."

Arriving at its head, we passed into a small lake which lay at the foot of an immense mountain. Climbing this mountain with my native guide, he pointed out to me the volcanic Mount Wrangel and the general direction the natives used to travel in going back to the Copper River. With this meager information, I returned to Nuchek, where, awaiting my arrival, I found the sealing schooner "Leo," which was to take my party back to Vancouver Barracks, where I arrived in the month of December.

The sum total of the exploration of 1884, while it developed the topographical features of the Copper River delta and Port Valdez, were of a negative character so far as developing an all-American route was involved.

V.
19

It was not until the year 1898 that this subject was again taken up by the War Department, when, owing to the friction between the American miner and the Canadian official in the Klondike region, the Secretary of War was directed by a Senate resolution to explore all possible routes of travel from the Gulf of Alaska through to the Yukon River with a view of discovering and locating an all-American route to the Yukon.

In the month of February, 1898, I was summoned to Washington for a conference with the Secretary of War and the General of the Army relative to the continuation of explorations from Prince William Sound to the Yukon River.

To carry out this work, the War Department had imported from Norway 557 reindeer, with sleds and equipment, and 113 Lapland drivers, herders, etc., with a view to using this transportation in pushing forward the explorations of an all-American route. After my conference, I proceeded

to Seattle, Wash., and organized one of three expeditions that would take the field. On the 8th day of April, 1898, I left Seattle with my expedition, following up the inland passage between Vancouver, Queen Charlotte, Admiralty, Barnhoff and Chicagof Islands and the mainland, leaving this passage at Cross Sound. From thence I proceeded over the Fairweather grounds, which lie south of Mount Elias and the Great Malaspinia Glacier and Kyak Island to Prince William Sound.

It was found, on arrival at the Haines Mission, that the reindeer for this work, owing to their long ocean passage and journey across the continent and the lack of proper food, were wholly unfit for further use. I landed my party at the head of Port Valdez, and at once organized small parties to push forward such explorations in Prince William Sound and through the near-by mountain passes as could be made without the use of pack-animals. I found, at Valdez and scattered over the Valdez Glacier, some 4,000 gold seekers, who had chosen this route with the idea of reaching the Yukon River. All were provided with small hand-sleds with which to transport their goods into the interior, intending, after the snow had melted, to continue their journey by pack, packing to some imagined point. Many had never been out of the sight of a factory chimney, and were wholly unacquainted with woodcraft or the ordinary means of traveling through new country. It is hardly a matter of surprise, therefore, to learn that 90 per cent. of these people never even reached the Copper River.

In the latter part of May, I took one of the various steamers that had come into Port Valdez with gold seekers and returned to Seattle, where I communicated with the Assistant Secretary of War, and received his sanction to purchase forty head of horses to push forward the explorations.

Leaving Seattle, I proceeded over the mountains to the North Yakima Indian reservation, and selected what I considered to be forty fair pack-animals, with which I left Seattle for Port Valdez in the latter part of June, where I arrived on the 8th of July. The glacier streams in and around Port Valdez had now become swollen to such an

extent as to render the crossing of them by pack-animals an impossibility without the construction of bridges. During my absence at Seattle, one of the party sent up through the Keystone Canyon, with instructions to cross over and follow down the Tasnuna River to the Copper River, had returned with the information that, barring the deep glacial streams to be crossed, there was no difficulty in reaching the Copper River from the head of Port Valdez. (This was the pass that I had attempted to find when accompanied by the two Russian half-breeds in 1884.) I now gave up all hope of reaching the Copper River by this route, as the season was so far advanced that it would be impossible to bridge even the smallest stream and obtain any results from exploration.

I then reorganized my party into four sections, one of which I took charge of, which was to take that part of the Copper River Valley from the head-waters to the point where we should strike the river after crossing the glacier. The second was placed in charge of Mr. F. C. Schrader, geologist, which was to explore and map that region along the Copper River south to the point reached by me in 1884. The third was in charge of Mr. Emil Mahlo, topographical assistant, who was to explore the Tonsena and Tasnuna River Valleys with a view to finding an outlet from the Copper River to Port Valdez. This work it was considered would practically take in all of the topography from a point about 180 miles north of the Copper River and 90 miles east of Port Valdez lying within the Copper River proper. The fourth expedition, under Lieut. P. G. Lowe, U. S. A., was to push exploration from the head of the Copper River to the Tomona River, and crossing that river, striking in somewhere on the head of the Forty Mile and down that stream to Eagle City, the intersection of the international boundary between Canada and the United States and the Yukon River.

On August 5th, notwithstanding that it had been raining and foggy for some five or six days previous, the four sections of this expedition moved up to the foot of the Valdez Glacier.

Prior to this I had kept men up on the glacier during clear weather building small stone monuments as guiding signs for us to follow in crossing over the mountain range. The Valdez Glacier, from its foot on the coast side to its termination in the Copper River Valley, is 30 miles long and 5,000 feet in altitude. This ice is formed, of course, by pressure, it being estimated that a column of snow 40 feet high with an atmospheric pressure of 15 pounds to the square inch will form ice by pressure. It is no uncommon thing on the summit of these mountains to see a fall of snow of 25 or 30 feet in depth. As the ice is formed on the summit it is forced into the valley below, and as it passes over inequalities in its road down to the low lands large fractures occur, which are known as crevasses; some of these on the Valdez Glacier were over 300 feet deep, and it was estimated that in some places the ice was over 800 feet thick. During the winter the snow forms an arch over these crevasses capable of holding the weight of a man or a horse, providing the tenacity of the snow has not been weakened by the sun's rays. It was by traveling over these snow arches that I hoped to take my pack train of some thirty or forty animals up over this glacier and down into the Copper River Valley. The one great danger that I could not guard against was the shifting of the wind when the summit was reached, as the mountains for many miles east and west were one continuous mass of ice; hence the building of small stone monuments, which we hoped to follow should it become stormy during our passage over the glacier.

Everything being in readiness so far as our glacial experience extended, we broke camp at 5 A.M. on the morning of August 6th and started up the glacier. As we rode on the ice I asked one of the men whom we depended upon to guide us over the summit what he thought our chances were of getting through, and he replied that if the wind shifted in the pass and we lost our bearings, I would stand a good show of losing my pack-train and most of the personnel of the expedition; but if the wind held fair we ought to be in the Copper River Valley by the following day. For convenience in handling the animals I had divided the train

into five animals to each section, each animal being led by a man, with an extra man in reserve to assist in pulling animals out of crevasses should they break through the snow.

Passing onto the glacier the animals seemed to know instinctively that there was danger ahead, as they would tremble and keep their noses close up to the backs of the men who were leading them. Whenever they broke through a snow arch, as they often did, they would lie still until pulled out by ropes. As the expedition passed up through one crevass and turned to make an ascent of some 50 or 60 feet up a grade of not less than 45° onto a cone of ice, it looked very much as if we were trying to make the horses climb up into the sky, the dense fog and the ice being about the same color. Now and then a horse would lose his footing and slide down to the bottom with a rush, but never once did one of them refuse to climb out of an ice gush when called upon to do so, although many times they left a trail of blood behind them where they had been cut and bruised in their fall.

Arriving at the top of the first bench, one of the inequalities heretofore referred to, caused by the glacier passing over a reef of rock (in its passage down the valley), the fog was so dense that it was impossible to see more than five or six animals of the train at any one time. Every once in a while we found that the melting ice had caused one of the stone monuments, which marked the trail, to topple over, when a halt would be called and our guide go forward just far enough to keep within hailing distance, when having found another monument, we would again push forward. In this way the train was kept moving during the day and well into the night, covering some 18 miles, when it became so dark that we halted and stretched our picket line, and unloading the horses tied them together for the night without taking off their saddles. The rain was now coming down in torrents. Not only was the night black, but the fog that came from the melting ice was extremely cold and penetrating. Occasionally the glacier would crack as it settled in its passage to the valley below, with a vibration that would cause the men to stop in their tramp and the horses

Valdez and Thompson Pass Sheet. One of the many sections which, as a whole, form the map of the All-American Route.

to whinny with fear; then would follow the deafening roar as some thousands of tons of ice that had been detached from one of the hanging glaciers that fringed the mountain side, would come crashing down onto the main glacier. Towards morning some of my men became so chilled and tired that it was necessary to administer a little stimulant. It was observed on this occasion that there were few prohibitionists in the party. This night, like others, came to an end.

At daybreak we repacked the animals and proceeded on

A section of All-American Route through Keystone Canyon, 14 miles from Valdez.

our journey toward the summit. Four or five miles were covered when we came to a section of the glacier known as the fourth bench, which was so bisected with deep crevasses that it looked impossible to pass over them; but by taking the train down one long narrow peninsula and doubling back on another, we, after some hours of careful work, regained the level above. The mental strain at this stage of the journey was terrific. The horses and men were so badly used up that it would have been impossible for them to survive another night on the glacier, and our progress through

this network of crevasses had been so slow that I was afraid we would not cross the summit in daylight. We were now up about 3,000 feet in slush and snow about knee-deep. Bearing off from the fourth bench to the right we managed to get our train onto a series of snow slides and made fairly good time to the foot of the sixth bench. This was the last raise of the glacier, which was 1,100 feet in one mile, or a climb of almost 45°. The fog had now given way before a violent wind, and as the pack train crawled up this ascent they looked like little birds going over the snow. On reaching the summit the wind was blowing a hurricane into the interior, accompanied by gusts of sleet and snow, which, freezing as they fell, coated man and beast with an armor of ice. All thought of trying to follow the monuments was now abandoned, as it was impossible to do anything with the horses except let them drift with the storm, which, fortunately for us, was in the direction we wished to travel. After traveling some five or six hours in this storm we could feel that we were making a descent, and knew that, barring accident of falling into a crevass, we would soon be in the Copper River Valley. Following down the pass, the weather rapidly moderated until we came out into a clear sky, still above snow-line. Here the men and horses sank down into the snow for half an hour's delightful slumber, while back of us out of the canyon howled the storm as black as night. Following on down the glacier we soon made camp and all felt greatly relieved to know that we had accomplished somewhat of a task in bringing a pack train of forty horses over a glacier thirty miles long and almost a mile in height.

On the morning of the 8th of August we continued our journey down to Klutena Lake, and following the shore of that body of water, camped at the eastern end near the base of a high mountain, where we gave our horses a much-needed rest and ascended the mountain, where we got a beautiful view of the Copper River.

Locating the most prominent mountains as a guide for our future travels we passed on down to the Copper River, where our parties were to divide.

On the 23d of August Mr. Schrader and Mr. Mahlo started down the Copper River Valley, while I, crossing the Copper River, began my journey toward the head waters. After some two days' travel, passing along the foot of Mount Drum and Sandford, I again struck the Copper River, a mere stream some 70 miles north from the point at which I parted with my assistants. Continuing my journey up one branch of the river, which afterward developed to be the Salina, I again came into a mountainous region, which

Mule train crossing Thompson Pass, June 1st, 18 miles from Valdez.

proved to be the main range of the Rocky Mountains. Camping at the foot of one of these high mountains I ascended to its summit, and with a strong pair of glasses was able to locate all the prominent features of the upper Copper River Valley.

Returning to camp, I found that we had but 25 pounds of flour, 5 pounds of bacon and a half pound of tea on which to feed myself and two packers on our journey back to our point of departure, which I estimated to be 175 miles dis

tant. Starting at once for a new pass that I discovered in the Salina River Valley, we reached that stream about 30 miles above its mouth. Finding that greater progress could be made through the timber by stripping the horses of their loads, we made a raft, and placing thereon our camp outfit and saddles, I took charge of the raft while my packers started down the river bank through the timber, to meet again at the mouth of the Salina. Turning south down the banks of the Copper River, we pushed forward with all haste, fording and swimming the small streams, arriving at the mouth of the Klutena River, the point at which we had parted with Mr. Mahlo and Mr. Schrader on the 27th of September, having lost but one of our horses, which became exhausted and was shot. Here I learned from miners that one of my parties, in trying to raft the Tonsena River, had met with an accident, whereby the raft was wrecked and one of the men drowned. Hiring a boat from one of the miners and getting together such food as I could buy, on the 28th of September I started down the river to Taral, an Indian village, 75 miles distant, where I expected to get information that would note the whereabouts of Mr. Schrader and his party.

On the 29th I passed through Woods Canyon and effected a junction with the Schrader party. Mr. Schrader informed me that he had followed down the Copper River to a point where the coast range and that of Mount Wrangel join, where he had abandoned his horses and continued his journey by boat. Turning over to this party the food that I had brought from the mouth of the Klutena River, I proceeded on down through the Bremner Basin and camped at the head of Abercrombie Rapids just above Miles Glacier. This was the point where in 1884 I had spent three months in trying to find the Copper River Valley. There had been great changes in the fifteen years elapsing between these two visits. The Miles Glacier itself was very much emaciated, great sections of the glacier having been cut out by the water; the current, while not so violent, was still of a character to preclude any thought of navigation under any condition.

On passing Childs Glacier, I noticed that it had also receded some 500 or 600 yards, possibly more, leaving in front of it some boisterous rapids. Continuing my journey on down through the Copper River delta, I passed out into Prince William Sound, and arrived at Port Valdez on the 15th of October, having covered a little more than 800 miles on foot, horseback and by raft since August 5th.

Some five days after my arrival at Valdez the Schrader party returned, having followed up the Tasnuna River from the Copper River and, passing through the Keystone Canyon, our party reunited at Valdez with the topography of almost the entire Copper River Valley, demonstrating the existence of an all-American route from Prince William Sound to the Yukon Valley.

[*To be concluded.*]

Correspondence.

CONTROLLING THE FLOODS OF THE MISSISSIPPI.

To the Committee on Publications.

GENTLEMEN:—"Du choc des opinions jaillit la vérité" Such was the impression when I received the May number of the *Journal of the Franklin Institute* and noted Prof. Lewis M. Haupt's answer to my remarks of December 19th, last. Graciously thanking him for the attention paid to my letter of above date, I beg to call attention to some mistakes, for which the imperfection of expressing my thoughts in a foreign language is probably responsible. Professor Haupt is positively in error when he supposes that I attempted to "apply the methods in vogue in Holland (Netherlands) for *reclamation* to those proposed in the United States for *navigation*." The strenuous efforts of the Central Service of the "Waterstaat" have, on the contrary, been to stop injurious land reclamation, and to create great navigable canals permitting the excess of flood-waters to escape easily into the sea. In these canals there is always a current, scouring the bottom and keeping it at the desired depth; the splitting into numerous small canals, when Δ-formation is allowed, was prohibited; no side canals but the river itself should bear the excess of flood-water; the river should conduct its own waters into the great herring-pond; the winter-road bed, which in summer is dry land, fertilized by the silt deposited in winter, should therefore not be encumbered by dykes, which interrupt the free flow of the water.

As for ice-dams, they did not obstruct the mouths of the rivers, bnt higher up they caused disastrous floods.

The tides, it is true, are an important factor in the creation of a navigable channel, but of course as far only as they are felt. Above Gorinchem (or

Gorcum) no trace of tide is perceptible; but, notwithstanding, the strenuous efforts of the Waterstaat have created a navigable channel, through which sea-going steamers can proceed with unbroken cargoes even to Cologne, in Prussia.

The absence of tides and ice facilitates, but does not change, the principles which govern the problem.

The system advocated by Professor Haupt, of outlets into side basins, as Lake Pontchartrain, Lake Borgne, is abhorred by the Waterstaat in the Netherlands, and should be much more so in a semi-tropical country like Louisiana. Stagnant pools are created, with all the attendant evils already specified in my December letter. The rivers of this colony (Java) are not yet put under such systematic control as those of our mother-country; they generally split up into numerous creeks before pouring their waters into the Java Sea; the Δs are for the greater part marshy and, consequently, sources of great unwholesomeness, as I can bear witness. Exposed for nearly four years to the miasma of the Δ of the Fji-Sadané, I sacrificed much of my health at the naval dockyard of Onrust. Where, on the contrary, as with the Solo River, the waters have been forced into the sea through one canal, without side-outlets, the strand is not unhealthful.

I cannot agree with Professor Haupt, when contending that the discharge of fresh water floods on the Holland rivers is very small, and that the tides are depended upon to maintain the depths. The basins of the Rhine, Meuse and Scheldt, although small when compared with the Mississippi, are in themselves not small. The Rhine is one of the greatest of European rivers. I regret having no figures at hand to compare its basin with that of the Mississippi. But there is no necessity for comparison, as the principles which govern the regulation of a small river are the same as those for a larger one; the works only have to be undertaken upon a relatively greater scale.

The same principles which govern the sailing of a whaleboat govern that of a large frigate. The absence of tides in our colonial rivers has not prevented the silting up of their mouths by Δ formation, as their presence in the Netherlands rivers has improved their canal-bed without the help of man. Let me add that the Yssel, which pours its waters into the Zuyderzee, an inland sea, without any perceptible rise or fall from tides, has been regulated upon the same principles, and the measures taken have been crowned with the same success as the works executed upon the other rivers.

The contention that there is no comparison as to the relative amount of sediment carried to sea ought to have been illustrated by figures; but even if there be a comparatively greater sediment carried to the sea by the Mississippi than by the Rhine, for instance, I still fail to see that other measures are justified for this one river, or that the principles which govern the sedimentation of one, have no bearing upon the other. The magnitude of the works may be influenced by such circumstances, but the principles involved, which should govern the engineer in removing the bad effect, remain the same, and are not influenced by latitude, magnitude of basin or intensity of sediment.

In his supposition that it is evident that the floods of Holland are derived mainly from the sea, Professor Haupt is quite astray from the road. For centuries sea inundations are unknown. The great inundations of 1861 and 1876, which did so much to urge the Waterstaat to hasten their work and execute

the Ferrand and v. d. Kun program, were essentially river inundations; the first one complicated by ice encumbrances; the inundated land, in the first named year, the Bommeler and the Fielerwaard, and in the second, the Bossche-veld, are above sea level, above tide influence even, and could not be inundated by the sea. All argumentation, based upon the erroneous supposition of the character of the floods, is consequently void of interest; it has, therefore, never been aimed to "dam the floods from the sea," but, on the contrary, to create as easy a way as possible towards the sea, by removing sand bars and other encumbrances, as dykes, etc., in the winter bed, by short cuts, by a broad mouth, and all those means advocated by Ferrand and v. d. Kun, and enumerated in my December letter (page 384). The works involved to carry out the program of these engineers are, however, heavy and expensive, and decade after decade has seen their systematic execution; but although far from finished, even in the unfinished state, they have, nevertheless, prevented the occurrence of disastrous floods in the last quarter century.

The damming up of the old Maas mouth near the Hoek of Holland is quite misunderstood; it was in order to replace the old crooked and narrow Brielsche gat, as it was called, by a new, straight and broad one of sufficient capacity to carry the waters of the Rhine into sea.

The destination of the Catwyk canal is also quite misrepresented by Professor Haupt. I did not write that it should "discharge its"—that is to say, the Rhine's—"superfluous water into the North Sea," but "to secure the *Waterschap of Rynland* ready means of discharging its superfluous water," etc. This makes a great difference; not a drop of the Rhine's waters is delivered into the sea by the Catwyk Canal. For centuries the Rhine did not deliver its waters through its old roadbed, along Utrecht, Woerden and Leyden into the sea; a sluice near Wyk by Duurstede prevented this delivery through its old roadbed, which, as before said, was smothered in the downs near Catwyk: its waters took partly the bed of the Lek, partly that of the Waal, and afterwards of the Maas. (Krayenhof had proposed to canalize the Lek and to retain only the Waal, sufficiently enlarged, to carry the Rhine waters into the Maas. It was quite rational to propose this, and quite in the line of his principle to minimize the splitting into smaller canals of a great river; and but for the great cost involved it would have been carried out.)

The rainfall of the waterschap of Woerden and of Rynland had to be carried into the sea, and *one* of the means to realize this was the digging of the Catwyk canal through the downs, with sluices to prevent inundation from the sea into the Waterschap of Rynland, when the sea level is higher than that of Rynland's boezem (bosom), that is to say, above the level of the canal, which collects the waters which the several polders throw into it, for subsequent carriage into the sea.

I hope in the above to have demonstrated that Professor Haupt has involuntarily quite misunderstood my meaning; that is to say, that the Waters aat in the Netherlands did not intend to dam the rivers against intrusion of the sea; but, on the contrary, to open the rivers as much as possible for the delivery of the flood waters, regulating them, and, at the same time, individualizing them. The Waterstaat's work has been largely to remedy the unsystematic work of centuries—the uncontrolled impoldering by dykes of

the sediments of the rivers. If Professor Haupt will only review what I have said before, and take into account the explanations of my present letter, I think he will be aware that we agree in almost the whole matter, with the exception of one point only, but a very especial one; that is to say, that of the creation of side outlets, and the allowing of Δ formation.

Whether the learned professor be wrong or not, I beg to illustrate by another example—the regulation of the mouth of the Danube, which was based upon the same principles as that of the Rhine and other rivers in the Netherlands; the exceptions taken against my referring to the success with these rivers cannot hold good in the case of the Danube; the Black Sea is without tides, and the sub-tropical climate of Bessarabia is a warrant against ice obstructions.

I have now come to the most difficult part of my answer—discussing the facts related by Professor Haupt about the work done in the Mississippi mouth. To discuss them in detail would not only intrude upon the space

FIG. 1.

FIG. 2.

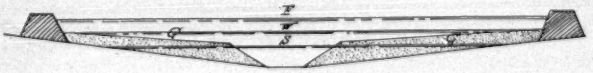


FIG. 3.

allowed for a discussion, but is, besides, impossible from the circumstance that the available data are insufficient for me to discuss them thoroughly. I cannot sound farther than my line goes, and can, therefore, only adhere to vague generalizations. There is, however, sufficient material available to convince me that in the engineering of the Mississippi mouth grave faults have been committed. The Waterstaat has always insisted upon the creation and maintenance of a distinct summer-, winter- and flood-bed. Let, in *Fig. 1*, *S*, for instance, represent the summer, *W* the winter, and *F* the highest known flood level; the space between *f* and *g* should remain undisturbed by dykes; no building should be allowed in this region. Farmers and cultivators have always a tendency to create quays (zomerkaden) near *g* to defend their property against the invading winter floods, but these should not be allowed. If the natural slope of the ground is less than in the former case, cribs should be created as at *C*, *Fig. 2*, in order to limit the river to its channel. If the river banks slope into the bottom of the river, cribs extending from summer level to winter level should define the summer and winter road-beds. As a rule,

riparian land-owners are allowed to build these cribs, and the reclaimed land is the property of the builders. If the Government builds them, it becomes the proprietor. If the banks are high and above flood level, as in *Fig. 4*, then excavation and dredging must assist the regulation work.

If, in these and in similar ways, appropriate winter- and summer-beds have been created, the régime of the river is such that it will maintain its depth without dredging or further assistance of man. In summer, when the discharge of water is small, the narrow bed will carry the water with sufficient depth to allow navigation; sufficient strength of current will be maintained to scour the bottom. In summer the water is always clearer than in winter, and the winter sediment will be scoured in summer. In winter, when the water is muddy, the river will deposit the greater part of its sediment upon the berms *fg* (*Fig. 1*), the current there being weaker than in the deep central channel. The fertilized berms will yield good crops in summer time. The

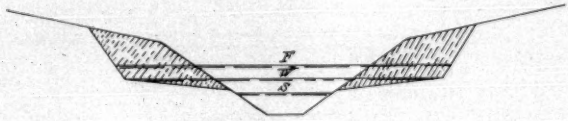


FIG. 4.

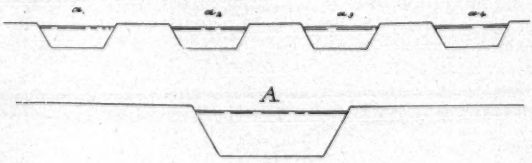


FIG. 5.

first rains will scour much of the deposited silt into the central channel, which will carry it into the sea. These berms are the secret of success. They protect the inner banks against inundation, and the central channel against silting up. From the illustrations accompanying Professor Haupt's original article in the October number of the *Journal*, 1903, I infer that the Mississippi banks are not systematically provided with such berms, and, if existing, the crevasses of 1903 on Bayou Lafourche prove that they are protected by dykes, which, as has been demonstrated, spoil the good work they should do, and, therefore, should strenuously be prohibited.

Another grave fault Professor Haupt's letter of March indicates, is the narrowing of the roadbed towards the end; on the contrary, the channel should gradually widen. With such faults I am not at all astonished that the Mississippi River Commission reports in 1903 that "to permanently locate and deepen the channel, has not been practicable under existing conditions." No better proof is necessary of my contention that your engineers are on the

wrong trail with the improvement works at the Father of Waters, than this clear confession.

There was one on the right track, the unsurpassed Eads. If his course had been followed I am sure the above words would have remained unwritten. But from what Professor Haupt says about the works executed at the South Pass, it is clear that the great man's work has been badly spoiled. It belonged to Eads' system to have only one outlet for the great river, exactly as it is aimed by the Waterstaat for the Rhine and other great rivers. Now it is ridiculous to contract such an outlet to a width of 600 feet for a river like the Mississippi! That other passes needed to be opened after the spoiling of the South Pass is as clear as daylight; the one fault engenders another.

Professor Haupt quotes the words of the *Enc. Brit.* (Holland, page 65). No better quotation could be resorted to than this to prove the beneficent character of the works of the Waterstaat. As I have already sketched out, before the French Revolution there was no central control over the rivers; the first propositions originated with Krayenhof; the first decades of the nineteenth century passed in deliberations and preparations; the latter decades in the vigorous taking in hand of the works. And now be pleased to look at the frequency of the floods before and after the systematic control of the rivers; 1876, not quoted by the *Enc. Brit.*, is the last flood year. In the last quarter of the eighteenth century no less than four great floods are recorded; during the whole of the nineteenth century not more than the same number are on record! Indeed, the quotation from the *Enc. Brit.* speaks volumes.

In concluding I beg to ask, What does the reader prefer: to split the mouth of a river into, let us say, four small creeks, like a_1 to a_4 in *Fig. 5*, or to concentrate the flow into one great channel A, of the same capacity as the four creeks together? Are not the greater depth and breadth of A essential advantages? Cannot larger and more seaworthy ships pass the channel A than the small creeks? Is not the proportion of channel-capacity with rubbing surface much more favorable with the large channel? Is not the friction much less with this than with the small creeks? Does not therefore the large channel alone afford a much freer outlet for floodwater than the four small creeks combined?

Professor Haupt derives an argument for the opening of the outlets of Cubitt's Gap and Jump from the cheap land reclamation; but this argument is irrelevant, as we are not considering land reclamation, but controlling of floods. Further, I cannot reconcile his contention that "the creation of a free discharge near the mouth to avoid the floods rapidly, would not injure the works of Captain Eads," with his previous remark, that the South Pass is fouling at the rate of 5 inches per annum. Really all Professor Haupt's remarks confirm me in the opinion that the Waterstaat is right when adhering to the canon that a river should depend upon its own roadbed to discharge its waters, and not upon side-way tappings, which should act as safety-valves. The less a steam-boiler blows off, the better its régime; constant or periodical blowing off of the safety-valves means a bad régime: a main steam-pipe unproportioned to the boiler capacity.

Let, therefore, the Mississippi Commission beware of the faults committed by our ancestors; a great river is not governed by small means; outlets, levées and such like measures are to be classed under the head of small

means, palliatives, half-measures. The Waterstaat engineers have attacked the problem of controlling the floods and thereby creating navigable channels in grand style; "aux grands mots les grands remèdes" has been the device which guided their actions; mutually they were in perfect harmony in the appreciation of the general character of the measures, and although in the execution, without a doubt some friction has occurred, there was unity in aim; the one did not spoil the work of his predecessor; a great end was aimed at, which was splendidly achieved. After 1876 nothing more is heard of disastrous floods in the Netherlands; the last on record in the Mississippi is that of 1903. In other words, the floods in the Netherlands have been controlled; those of the Mississippi not yet.

Finally, I beg again to thank Professor Haupt for referring to me as "distinguished." He does me more honor than I expected or deserve; not less gratified I was with his addressing me as a friend, which I beg to reciprocate; and in thus taking leave of him, it is only in the hope that we will meet again in defending the Father of Waters against floods and sedimentation!

Respectfully yours,

H. VAN MEERTEN.

Member of the Institute.

BUITENZORG, JAVA, June 16, 1904.

Notes and Comments.

RECENT ELECTRO-CHEMICAL DEVELOPMENTS.

Two patents granted on May 17th to Mr. Alfred H. Cowles, of Cleveland, refer to methods of manufacturing calcium carbide. There is nothing new of a fundamental nature in his method since the carbide is produced simply by heating a mixture of lime and carbon to a high temperature. The patents refer rather to details of the method. Mr. Cowles intends to make the operation continuous and superheats the carbide so that it may be easily tapped off.

A patent granted to Mr. R. N. Pelton, of Detroit, Mich., refers to an electric furnace for dentists. Its essential part is a muffle with a heating coil of platinum wire in the wall. The outside of the muffle is surrounded by another heating coil.

Mr. P. J. Boucher, of Cleveland, Ohio, patents an apparatus for purifying water by electrolysis with the aid of aluminum electrodes. As well known, a flocculent hydrate is thereby produced, which coagulates the various impurities and allows them to be easily removed from the liquid by settling or filtering. If the current always goes in the same direction, deposits form on the electrodes and interfere with their action, and the electrodes unequally deteriorate. To counteract this tendency, the inventor automatically reverses the current at predetermined periods of time. He also provides means for automatically relieving the pressure of the gases evolved by electrolysis and for insuring the current being turned on or off whenever the liquid is turned on or off.

A patent granted to Mr. F. Hinz, of Berlin, Germany, refers to a process of manufacturing peroxides of magnesium and zinc in a diaphragm cell. For making magnesium peroxide he uses an aqueous solution of magnesium chloride in the anode compartment and a neutral solution of magnesium chloride and hydrogen peroxide in the cathode compartment. Magnesium deposited on the cathode by the action of the current reacts with the hydrogen peroxide and yields magnesium peroxide.—*Electrical World.*

WIND-MILL FOR ELECTRIC POWER.

Harnessing the wind to generate electricity for farm use is no longer a novelty. The first of these wind-mills were used experimentally to generate electricity for lighting houses and barns; success has since stimulated attempts to use them for more ambitious projects. To-day a good many are being run to generate power to operate small motors. The use of wind-mill power for generating electricity was tried successfully two years ago in Europe, and now at Hamburg and Leipsic are electrical plants which derive their motive power entirely from the wind. The wind-mills are strongly built, and are designed to take the wind at any angle. The regulation of the motor is effected by an automatic switch, which cuts out the battery when the wind falls to a low pressure.—*Iron Age.*

THE POSSIBLE UTILITY OF THE SUN SPOTS.

Sir Norman Lockyer, the British astronomer, has advanced a remarkable new theory concerning the utility of sun spots. Our knowledge of sun spots is distinctly limited, and Sir Norman Lockyer contends that the discovery and understanding of these phenomena will prove one of the most beneficial additions to the world in general. He advances the theory that such knowledge may enable astronomers to convert the sun into an agent to enable us to cope with droughts and famines, and that the spots on the sun may render it possible to predict with practical certainty the coming of famine and the exact part of the world where it will take place.—*Scientific American.*

COAL IN NEVADA.

On account of the scarcity and high price of all fuel, the occurrence of coal, even of inferior quality, within the desert region of Nevada, is a matter of great interest. At the north end of the Silver Peak Range, in Esmeralda County, just south of the road between Silver Peak and Candelaria, coal beds occur in Tertiary formations. These beds have been recently visited by Mr. J. E. Spurr, of the United States Geological Survey, who has described them in a paper published in Bulletin No. 225, which is entitled "Contributions to Economic Geology, 1903."

This coal is said to have been discovered by William Grozenger, of Candelaria, in 1893, and the seams are now continuously located. The chief seams are four in number and some of them extend for a distance of 3,000 or 4,000 feet in outcrops that trend in a northwesterly and southeasterly direction. Mr. Grozenger has classified the veins, counting from the top, as the first,

second, third, and fourth veins. The distance between the first and second veins perpendicularly is estimated by him to be 150 feet, between the second and third, 70 feet, and between the third and fourth, 130 feet. The uppermost vein, No. 1, seems to be relatively poor and small, and, as exposed in outcrop, of little value. Vein No. 2 is in coal shales and is several feet thick. The vein contains considerable slate parting or bone. Vein No. 3, which is also in the coal shale, is of better quality and thicker than No. 2. No. 4 shows 6 to 8 feet of coal of much better quality than the upper veins. Some of this coal has a brilliant lustre, while the coal of the other veins is dull in color. It is used as a forge coal by Mr. Grozenger and affords a coke. The coal contains a smaller per cent. of ash than that of the upper veins.

These prospects have been bonded several times. The chief prospecting has been on the upper veins, and the coal developed has been so light in nature and so full of ash that prospecting has been repeatedly abandoned. It seems, however, that the lowest vein has been somewhat neglected and possibly this may be found in the future to be available as fuel. The outcrop of this vein is limited and broken near the fault, but its underground extent must be great. Inasmuch as the beds underlying this seam are not exposed on account of the fault, it is not impossible that still other seams may occur beneath it.

The numerous mining enterprises which have been recently developed in this region, where there is no water power, little wood supply, and only expensive transportation, make even these coals, which are undoubtedly poor in quality, important. Since they all contain a large percentage of volatile matter, the gas in them might be separated and profitably used for fuel.

EFFICIENCY OF THE NERNST LAMP.

L. R. Ingersoll has redetermined the efficiency of the Nernst lamp by Angström's method, in which the total spectrum of the light is dispersed in order to separate out the visible spectrum, and the visible rays are then recombined by means of a cylindrical lens and thrown upon a bolometer or thermopile. The glowers were burnt freely in air, without heaters, on a 100-volt alternating current. A voltmeter and wattmeter across the terminals of the glowers and a rheostat in series enabled the author to keep the voltage or power consumption constant at any desired value. The principal factors in the determination of the efficiency of any glower are its age and the power it consumes. The experiments showed that Nernst glowers are by no means uniform. New glowers show an efficiency of from 4·35 to 4·70 per cent. The efficiency falls rapidly for about the first twenty hours, decreasing to a mean of 4·3 per cent. and varies only slowly after this. Tests of glowers of forty hours' age and upward gave a mean efficiency of 4·17 per cent. Some very old glowers gave only 3·6 per cent. It is noticeable that after a glower has been burned upward of twenty hours it develops a marked crystalline appearance, and it is probable that the fall in efficiency is due to the greater radiating surface and consequent lower temperature afforded by the crystalline structure. The author adds that if, as is now proposed, the glowers are aged before they are sent out, the deterioration with time may no longer be observable. As regards Hartman's observation, that old glowers show an increase in luminous intensity, the author points out that Hartman kept the current

constant rather than the power consumption. As the resistance of the glower increases with age, a constant current means an increased power consumption, and hence a greater emission.—*L. R. Ingersoll, Physical Review, November, 1903.*

DISTILLATION OF METALS.

Experiments carried out by Moissan and O'Farrelley, with the aid of the electric furnace, show that the usual laws of distillation apply as well to the distillation of mixtures of metals (*Comptes Rendus*, 1904, p. 1659). Various mixtures were heated in the furnace for different times, and the residues were analyzed. In the case of copper and zinc and copper and cadmium, the zinc and cadmium were completely expelled after short periods of distillation. In the case of copper and lead, the same result was reached, though only after longer distillation, during which the percentage of lead gradually lessened. In the case of copper and tin, some mixtures gradually increased in copper content, some in tin content, and others distilled without change of composition. With mixtures of lead and tin, the lead gradually decreased until pure tin remained. A remarkable character of tin is the wide range of temperature through which the metal remains liquid; while it melts at 226° C., its boiling point is above that of copper and lead.—*Iron Age.*

Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, September 21, 1904.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 21, 1904.

PRESIDENT JOHN BIRKINBINE in the chair.

Present, 86 members and visitors.

Additions to membership since last meeting, 35.

The major portion of the evening was given up to a discussion of the question of "The Use of Copper Sulphate as a Germicide for the Purification of Potable Water," with particular reference to the applicability of the process to the local water supply.

The discussion was opened by Dr. Hobart A. Hare, of the Jefferson Medical College, who, after referring to the experiments made by Drs. Moore and Kellerman, of the U. S. Department of Agriculture, which indicated that very small additions of copper salts to drinking water sufficed to destroy the vitality of typhoid bacilli, stated that similar experiments made in the bacteriological laboratory of the Bureau of Health by Drs. A. H. Stewart and Mary E. Pennington, had not only confirmed the results of the Washington experts, but had also demonstrated that the presence of one part of copper in 4,000,000 of water was sufficient to destroy all typhoid germs in three hours, a solution forty times weaker than that indicated as efficient for the purpose by the Washington experiments.

Dr. W. J. Williams, chemist to the Frankford Arsenal, admitted the efficiency of copper as a germicide, but held that its value from the standpoint of

public health would depend entirely on the care and intelligence with which it was applied in practice.

Mr. John C. Trautwine, late Chief of the Philadelphia Water Department, presented some data collected by Prof. Robert Fletcher, of Dartmouth College, Hanover, N. H , relative to the use of copper sulphate for treating the public water supply of that town to destroy and check the growth of offensive algae, with which it was contaminated. The introduction of one part of copper sulphate to 4,000,000 parts of water, trailed through the reservoir in a bag, not only effected the total destruction of the objectionable organisms at the end of sixty hours, but also so effectually purified the contents of the reservoir that, at the end of ten weeks, the water exhibited no recurrence of the pollution.

Drs. Stewart and Pennington, of the bacteriological laboratory of the Bureau of Health, gave an account of their experiments, above referred to.

Mr. John W. Hill, Chief of the Bureau of Filtration, at the invitation of the President, gave his views of the subject. Mr. Hill affirmed his confidence in the efficiency of thorough filtration, and instanced the results obtained at the Roxborough and Belmont filter plants, where from 97½ to over 99 per cent. of the bacteria present in the raw water were shown to be destroyed. He objected to the use of copper salts for this purpose, first, on the score that its application would be costly ; and, second, for the reason that the use of any chemical method of purification was objectionable, on general principles.

Remarks on the subject were also made by Prof. C. B. Cochran, Dr. G. H. Meeker, Medico-Chirurgical College, Philadelphia; Dr. G. Goldsmith, and Messrs. P. A. Maignen, Wm. L. Dubois and Reuben Harries.

Dr. Edward Martin, Chief of the Bureau of Health, in closing the debate, claimed that the value of copper as a germicide had been fully demonstrated, and while not denying the value of the costly filtration system now in course of completion for the betterment of Philadelphia's water supply, referred to the fact that this important work would not be completed for several years, and inquired if in the meantime our citizens should not be given the benefit of the copper germicide treatment, by which doubtless many lives would be saved which otherwise would fall a sacrifice to typhoid fever.

The Chairman expressed the thanks of the meeting to the contributors to the discussion.

Mr. Walter Zimmerman, of Philadelphia, Vice-President of the American Federation of Photographic Societies, presented, in brief, a plan for the collection of historic photographs in all parts of the United States, in which the co operation of the Franklin Institute is solicited.

On the Secretary's motion, duly seconded, the following resolution was adopted :

Resolved, That the proposition of Mr. Walter Zimmerman on behalf of the American Federation of Photographic Societies, be referred to the Section of Photography and Microscopy with a favorable recommendation, and the further recommendation that Mr. Zimmerman be requested by the section to serve as a member of any committee which it may appoint to give consideration to the subject.

Adjourned.

WM. H. WAHL,
Secretary.